THE PRACTICAL DICTIONARY OF MECHANICS

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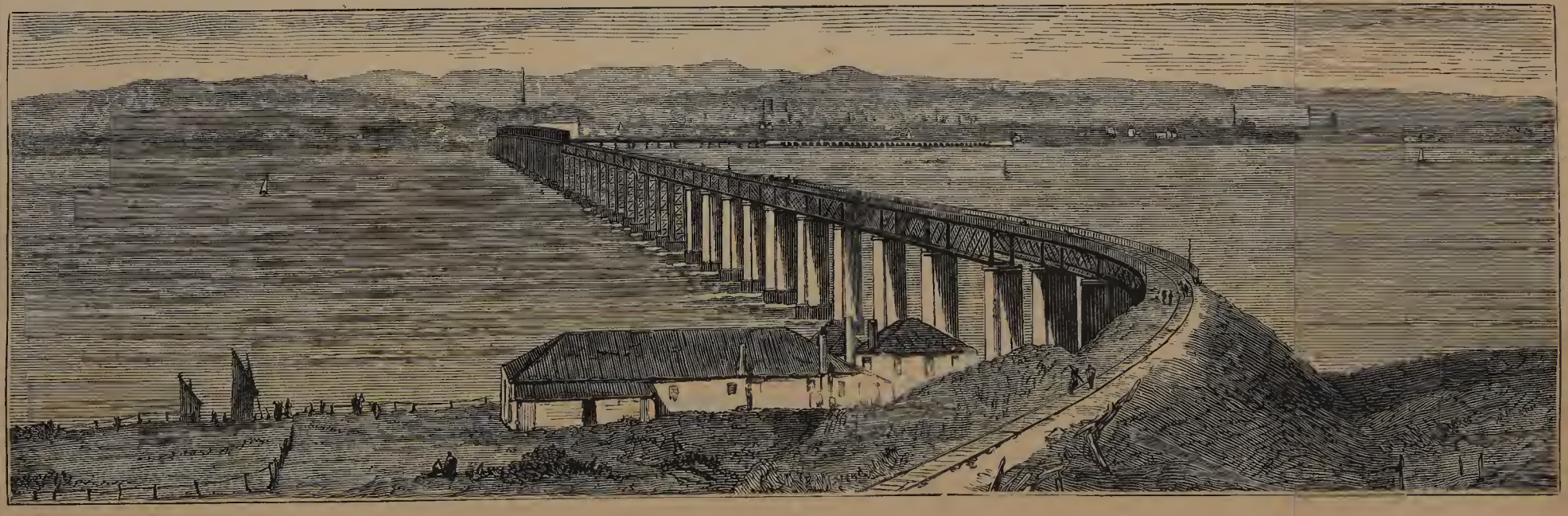

THE FIRST TAY BRIDGE, NEAR DUNDEE, FROM THE SOUTH.

See page 1200

THE

PRACTICAL

DICTIONARY OF MECHANICS:

BEING

A DESCRIPTION OF TOOLS, INSTRUMENTS, MACHINES, PROCESSES, AND ENGINEERING; HISTORY OF INVENTIONS; GENERAL TECHNOLOGICAL VOCABULARY;

AND

DIGEST OF MECHANICAL APPLIANCES IN SCIENCE AND THE ARTS.

By EDWARD H. KNIGHT,

CIVIL AND MECHANICAL ENGINEER, ETC., U.S.

Illustrated

WITH UPWARDS OF FIVE THOUSAND ENGRAVINGS.

DIVISION I.

"Thus Time brings all things, one by one, to sight,
And Skill evolves them into perfect light."

LUCRETIUS, Book V.

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PREFACE.

KNIGHT'S MECHANICAL DICTIONARY, an American work, contains an immense amount of matter that is both interesting and valuable to the English reader and student. The Author spent many years in collecting materials for the work, and in the actual preparation of it he obtained the assistance of writers thoroughly qualified to deal with the various subjects in the departments of Science and Industry. That there is great need of such a work as the MECHANICAL DICTIONARY—comprehensive, exhaustive, and accurate—its success in the United States may be taken as the best criterion; and there is no reason to doubt that it will be equally successful and serviceable in this country. The general plan and scope of the DICTIONARY are thus explained in the following extract from the original Preface, signed by the Author, Mr. EDWARD H. KNIGHT:—

"As to the general scope of the book and the method pursued in its preparation, it must, in the main, speak for itself. While the greater portion of the work is occupied, of course, by details of solid import, there is some little romance and a great deal of interest in the study of the *History of Inventions*. Without deviating into irrelevancy, the author has sometimes become

'A snapper-up of unconsidered trifles,'

worthy of a more careful estimate.

"When we read Pliny's account of the reaping-machines in the plains of Rhœtia, about A.D. 70, we wonder that, the idea once blocked out, the machine should afterwards relapse into utter oblivion. It was the time that was 'out of joint.' At the latter end of the last century and the early portion of the present, attention was again directed to the reaper, and the machine described by Pliny, and by Palladius three centuries later, was re-invented exactly: it yet survives in our *clover-header*. This instance is by no means singular. One favourite form of rotary steam-engine, upon which treatises have been written within two years past, is but a reproduction of the æolipile of Hero, which revolved in the Serapeum of Alexandria in the second century B.C. Many similar examples might be cited, but this duty belongs to the body of the book, and not to the Preface.

"In the adaptation of machinery to common use, our country excels all others: for instances, the reaper and the sewing-machine. These became useful instruments in American hands, not merely by facility of adaptation, but, most distinctly, by the invention of those all-important points which constituted success. A reasonable share of space in this work, therefore, has been devoted to the feature of *Mechanical Evolution;* the aim being to give not only the present state of the respective arts, but also the various stages by which the relatively perfect appliances attained their development.

"*Subject-matter Indexes* are introduced in their alphabetical order throughout the body of the work, and a list of the principal ones follows this Preface. These will afford means for ascertaining the names of the technical implements of the respective Arts, Manufactures, and Trades, and also serve as cross-indexes for the terms so cited. The subjects indicated are necessarily considered in their alphabetical order; for instance, the five hundred 'Agricultural Implements' are not treated in a single article—as they would be in an Encyclopædia—but each in its own place, under its own name. Their assemblage, however, in a single list, or index, is convenient for many purposes, and it is estimated that over twenty thousand technical words have been thus gathered in groups.

"EDWARD H. KNIGHT."

LIST OF SPECIFIC INDEXES.

The Specific Indexes in the following list are to be found in their alphabetical places in the body of the Work. Each Index embraces the Technical Appliances, &c., appertaining to its subject.

Agricultural and Husbandry Implements.
Air Appliances and Machinery.
Alarms.
Alloys.
Artificial and Prosthetic Appliances.
Astronomical Instruments.
Axes.
Baths.
Batterics.
Bits, Boring.
Blacksmith's Tools and Appliances.
Blocks, Nautical.
Boats.
Boilers.
Bolts.
Bookbinder's Tools and Processes.
Boxes.
Bridges.
Brushes.
Calculating and Mcasuring Instruments.
Carpentry.
Carpets.
Carriages (*see* Vehicles).
Cars.
Cements.
Chairs.
Chisels.
Civil Engineering.
Clamps.
Compasses.
Cooper's Tools
Cotton, Flax, Wool, Hemp, and Silk.
Couplings.
Currier's Tools.
Dental Apparatus and Appliances.
Dilators.
Docks.
Domestic Appliances.
Drafting Instruments and Appliances.
Drills.
Dryers.
Electrical and Magnetical Appliances.
Engraving.
Escapements.
Fabrics.
Faucets.
Files.
Filters.
Fine Arts.
Fire-arms.
Forceps.
Forks.
Fortification.
Founding.
Furnaces.
Gages.
Gas Appliances.
Gearing.
Glass.
'Graph.
Grinding and Polishing.
Grinding-Mills.
Hammers.
Hoisting-Machines.
Hooks.
Horological
Hydraulic Engineering and Devices.
Ice, Manufacture and Uses of.
Indicators.
Jacks.
Jaw Tools.
Joints.
Keys.
Knitting.
Knives.
Lamps.
Lathes and Appliances.
Leather, Tools, Machines, and Appliances.
Lenses.
Levels.
Lights and Photic Appliances.
Locks.
Looms (*see* Weaving).
Masonry and Architecture.
Measures.
Metallurgy.
Metal-Working Tools and Machines.
Meters.
Micrometers.
Mills.
Mining Appliances and Terms.
Musical Instruments.
Nails.
Nautical Appliances.
Needles.
Optical Instruments.
Optical Toys, Scenes, and Effects.
Ore (*see* Metallurgy).
Paper.
Photography.
Piles.
Pipes.
Planes.
Plasterer's Tools and Work.
Plows.
Plumbing and Sheet-Metal Work and Tools.
Pottery and Clay.
Presses.
Printing.
Projectiles.
Propellers.
Pulleys.
Pumps.
Punches.
Pyrotechnics.
Rails.
Railway Engineering and Plant.
Registers.
Regulators.
Rollers.
Saddlery and Harness.
Sails.
Saws.
'Scope.
Sewing-Machines and Attachments.
Shears
Shipwrighting.
Signals.
Speculums.
Springs.
Steam-Engine (Parts and Appliances).
Steam-Engines (Varieties).
Stoves and Heating Appliances.
Sugar-Machinery.
Supporters.
Surgical Instruments and Appliances.
Syringes.
Telegraphs.
Telescopes.
Tinman's Tools.
Tobacco.
Traps.
Tubes.
Turning-Tools.
Type.
Valves.
Vehicles (Tools, Appliances, and Parts of).
Vehicles (Varietics).
Ventilators.
Vessels.
Watches.
Water-Elevators.
Water-Wheels.
Weapons and Accoutrements.
Weaving.
Wheels.
Wire-Working.
Wood-Working Tools and Machines.
Wrenches.

KNIGHT'S MECHANICAL DICTIONARY.

A.

Ab'a-cis'cus. A small square stone or tessera for a tesselated pavement.

Ab'a-cus. An instrument used from time immemorial in performing the operations of addition and subtraction.

A smooth board with a marginal ledge formed the writing and calculating table of the Greek schoolboys and accountants. For writing, it was strewn with sand, upon which marks were made with a stylus; thus they learned to write, and on this they executed geometrical figures. The primary use of the board is indicated by its name, which is derived from the first three letters of the Greek alphabet, Α Β Γ. It was called an *abax*, and retains the name, but slightly modified.

The *abax* strewed with sand is the *pulvis eruditus*, or the *Mensa Pythagorea* of classic authors.

For arithmetical calculation, the same board was used without the sand, to contain the counters, which were arranged thereon in parallel rows, representing respectively units, tens, hundreds, thousands, etc. Solon (about 600 B. C.) refers to the arbitrary denominations of the several lines, in a metaphor which compares the different grades of society to the different values of the counters in the several rows.

The counters were pebbles, beans, or coins, especially the former. The Greek word for the counters of the *abacus* was derived from a word signifying a pebble. Pythagoras, the great arithmetician, hated beans, — an antipathy he derived from the Egyptian priests, his instructors. About the same time Daniel was eating pulse in Babylon without grumbling, and Horatius was hewing down the bridge of the Janiculum.

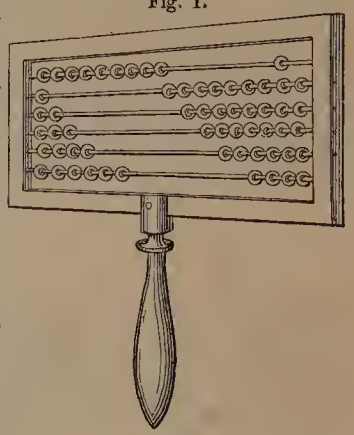
The Roman word *calculus*, from which we derive our word *calculate*, was the diminutive of *calx*, a stone, and referred to the pebbles which formed the counters of the abacus.

Sometimes the counters were shifted to the right in counting, sometimes to the left. It is stated that the Greek and Roman practices differed in this respect. Several varieties of instruments are represented on the ancient monuments.

The step was easy from a flat board with shifting counters arranged in rows, to a board with grooves in which the pebbles were rolled. Afterwards we find pellets strung upon wires, and thus the Chinese have used it for ages.

The illustration shows the last-mentioned form of the device, arranged for decimal counting. The number indicated by the beads on the right hand of the frame is 198,764, and it will be seen that by transposing the beads to one side or the other; as required, either addition or subtraction may be readily performed. A person accustomed to the instrument will perform these operations with great rapidity and accuracy. The Chinese term the instrument a *swan-pwan*, and are very dexterous in its use.

Fig. 1.



Abacus.

The original of the Chinese abacus has been supposed to be the "knotted cord," used in China for keeping accounts before the invention of writing. The knots are made movable by substituting sliding beads. Hence likewise seems to have been derived the mode of keeping the Chinese *Tung-tien*, or perforated coins, which are strung upon a cord.

One form of the Chinese abacus has two compartments, five beads in one and two in the other; the former have the value of one each, the latter five each. The wires are nine in number, and each runs through the two compartments.

The Romans, contrary to the customs of the Phœnicians and Greeks, from whom they received their alphabet, expressed their numbers 1, 2, 3, not by the first letters of the alphabet, but by strokes,

I II III;

in this respect unconsciously copying the Chinese numerals of the same value,

一
二
三

The difference in the direction of the figures gives the numerals in each the same position *across* the column; for the Roman writing is in horizontal column, the Chinese vertical.

The resemblance between the Chinese and Roman numerals extends much further than the above, and shows a common origin.

Perhaps it may be accounted for by the studies of Pythagoras in India, and the subsequent instruction of Numa in the school founded by the sage of Samos in Crotona, a city of Magna Græcia. (*Plutarch.*)

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Hindoo (commonly known as "Arabic").	Roman.	Chinese.
10	X	𝍠
11	XI	𝍡
12	XII	𝍢
13	XIII	𝍣
20	XX	𝍤
30	XXX	𝍥

The resemblance cannot be accidental. Pythagoras and Kung-fu-tze (Confucius) were contemporaries.

Another mode among the Chinese of expressing 20, 30, etc. was by placing 2, 3, etc. before the sign of ten; so that they in some degree anticipated the Hindoo, where a numeral before the zero expressed so many tens, e. g.

Chinese.	Arabic.
𝍦	30

The great advance in the Hindoo over the other systems of notation was in giving a *place value* to figures. In Sanscrit, the initial letters of the Sanscrit names of the Indian numerals are employed from 1 to 9. The original zero was a dot. The Greek letter omicron (o) was afterwards substituted, and forms our naught. It is amusing to see the combination of Hindoo and Roman figures during the fourteenth and fifteenth centuries, such as

(Written.)	(To be read.)
x 3	13
x 4	14
40 1	41, etc.

Showing that the force of the zero and the value from position were not understood at first, even when the new characters had become customary.

The decimal and duodecimal systems of arithmetic were in use in Egypt at the earliest period of its known history. For the respective systems the numbers of counters in the rows would vary, each line representing a multiple by 10 or 12 of the line below it. There is no representation of the abacus for counting on the Egyptian monuments. "The Assyrians counted by 60's as well as by 100's."—*Rawlinson.*

The instrument was probably invented by the Chinese, and passed thence westwardly through India and Arabia to Europe. The evidences of ancient trade on this line are found at both ends and at intermediate points. The glass bottles with Chinese inscriptions, found with the Egyptian mummies, prove the existence of trade relations between those nations before the founding of Athens, and also dissipate the myth of Pliny as to the discovery of glass by certain mariners of Phœnicia, a few centuries previous to the time at which he made his curious collection of vagabond information.

Over this famous route travelled the mariner's compass, gunpowder, the art of glazing pottery, of making paper of pulp, and much else that we value. Felting of animal fiber was also derived from Asia, but probably entered Europe by a more northern route.

The Greek and Roman numeration was decimal, but their system of notation was very unfortunate, as any one may ascertain by trying a sum in multiplication:

CCXLVIII
XLV
———
?

The Oriental system of notation was introduced by the Arabs, and was credited to them, but they more properly term them *Indian* numerals, referring to their derivation from the Hindoos. This system of notation passed with the Saracens along the northern coast of Africa, and was carried by them into Spain. The caliphate of Cordova was established by Abderahman, A. D. 755, and the university at that place was founded A. D. 968. At this distinguished seat of learning was educated the famous Gerbert of Auvergne. This enlightened ecclesiastic was successively a schoolmaster at Rheims (where he introduced the abacus, the Arabic numerals, the clock, the organ, and the globe), archbishop of Ravenna, and, eventually, Pope Sylvester II., to which position he was elevated by the decree of the Emperor Otho III. Patron and prelate died of poison shortly after, about A. D. 1002.

Gerbert was probably the first to use in a Christian school the nine digits and a cipher, which proved, as William of Malmesbury said, "a great blessing to the sweating calculators."

A translation of Ptolemy, published in Spain in 1136, used the Hindoo notation. The Hindoo numerals were introduced into England about A. D. 1253.

The accounts of the kings of England, previous to the Norman Conquest — and the same is probably true of most contemporary European nations — were calculated by rows of coin disposed as in the abacus, that is, placed in parallel rows which represented gradually increasing denominations in the ascending series. At the Conquest an amplification of the same idea was introduced, the calculations being performed by the *teller*, at a large table called a *saccarium*. This had a ledge around it, and was covered by a black cloth ruled with *chequer* lines. Hence the word *Exchequer*, as applied to English national finances.

In the twelfth century, this table was five by ten feet, and its cloth cover was divided by vertical and horizontal lines. The horizontal bars represented pence, shillings, pounds, tens, hundreds, thousands of pounds. Coins were used for counters; the first and lowest bar advanced, by dozens, the number of pence in the shilling; the second, by scores, the number of shillings in the pound; the higher denominations by tens. This was a true *abacus*, and was used down to a comparatively recent period.

The accounts of merchants were kept in Roman numerals till the close of the sixteenth century, and the use of the abacus was maintained to a much later date. Until 1600 its use was a branch of popular education.

Offices for changing money came to be indicated by a checker-board, and the sign was afterwards appropriated by the keepers of inns and hostelries. This shows that people met at such places to settle accounts, a friendly drink being a tribute to "mine host." The Jerusalem and Lloyd's coffee-houses are noted in the history of trading companies; the latter especially. The checker-board on the doorpost of the tavern is about the last phase of the *abacus*, in Europe at least.

The checkers on the posts of an inn door are to be seen upon a house in disentombed Pompeii.

The *tally* system was also introduced into England at the Norman Conquest. This was not for calculating, but for keeping accounts. The name of the device came with it across the Channel, being derived from the French *tailler*, to cut, the *tally-sticks* being cut and notched with a knife. A squared stick of hazel or alder was prepared, and the money account was notched on the edge, small notches representing pence; larger, shillings; still larger, pounds. The stick was then split longitudinally, so as to leave notch-marks on each portion; one part was laid away in the exchequer strong room, the

other was given to the creditor of the government. When the person came for payment, his portion of the stick was laid against that in possession of the exchequer, and if they *tallied* the claim was admitted, perhaps paid.

This system survived the introduction of Arabic numerals into England about 670 years. In 1826 the time came for the venerable system to abdicate in favor of the other Oriental method which had been asserting itself for so long. The pile of sticks, in companies, regiments, and brigades, that had by this time accumulated was something terrific. The question was, How to get rid of them? Prescriptive custom would prevent their being issued to the poor, or sold to bake the bread of the people, as the Alexandrian library heated the baths of that imperial city; so one fine day in 1834 they were to be privately burnt. A stove in the House of Lords was selected as a proper place for the incremation of another relic of the past; the wainscoting of the chamber protested by catching fire, the House of Lords set fire to the House of Commons, and both were burnt to the ground, — a grand funeral-pile.

The bakers insisted for some years in keeping tally-stick record of loaves purchased by their customers; some of us recollect it.

The oldest surviving treatises on mathematics are by the famous Alexandrians, Euclid, about B. C. 300; Ptolemy, A. D. 130; and Diophantus, A. D. 156.

Decimal fractions were invented 1482.

The first work on arithmetic published in England was by Tonstall, Bishop of London, 1522. The Italians had been in that field many years before.

(*Architecture.*) The crown member of the capital of a column.

Ab'a-ka. A fiber from which Manilla-rope is made. Ropes and cables of this material float in sea-water.

Ab'a-mu'rus. A buttress or second wall, built to strengthen another.

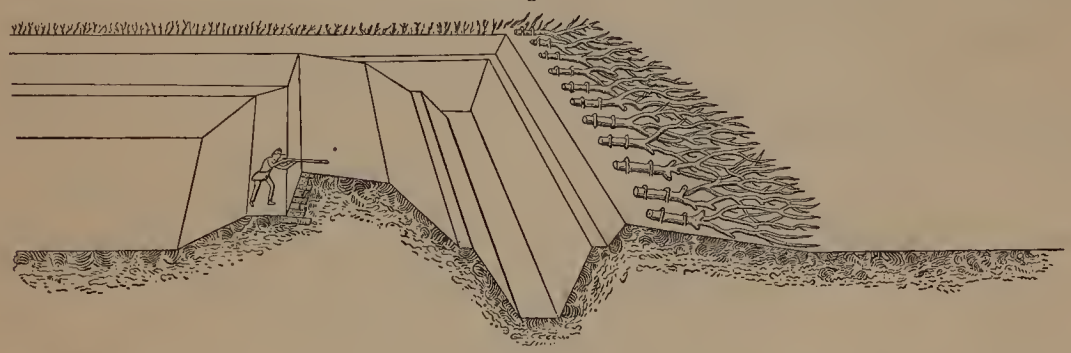
Ab'ap-tis'ton. (*Surgical.*) A trepan saw.

Ab'at-jour'. (*Building.*) A skylight, or aperture for the admission of light.

Ab'at-voix'. A sounding-board over a pulpit or rostrum.

Ab'at-tis. (*Fortification.*) An obstacle employed in military operations for delaying the approach of an enemy and keeping him under fire as long as possible. It is formed of trees or large limbs having the branches under two inches in diameter chopped off, the larger ones being sharpened and interlaced, and pointed toward the enemy. The butt ends

Fig. 2.



Abattis.

are secured by pickets, and may be partially embedded in the earth to prevent them from being readily removed.

Abattis are usually placed in front of the ditch in field fortifications, but they may be placed in the ditch against the counterscarp; in the former case they should be protected from the enemy's fire by a small glacis.

In a wooded country an abattis is readily formed by felling the trees in such a way that their branches shall interlace, leaving the trunk connected to the stump by a portion not cut; the stump should be high enough to protect a man behind it.

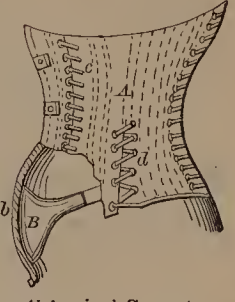
A small parapet formed of logs and backed by earth may be thrown up in the rear of the abattis, which thus constitutes a very efficient and available means of defence.

The abattis is referred to by Herodotus, Thucydides, and Xenophon, and was a common military defence derived from savage life. An abattis of thorny shrubs or limbs is the usual defence of an African *Kraal* against predatory beasts.

Abb. (*Weaving.*) Yarn for the warp.

Ab-dom'i-nal Sup-port'er. A bandage for the compression of the relaxed abdominal walls, intended to assist the muscles in holding the viscera in place. The simplest are made of elastic rubber covered with silk or cotton; they encircle the body from the navel to the pubes. Others are made of two steel springs passing over the crests of the pelvic bones, with a small pad resting on either side of the spine, and a large frontal one; their position and action being similar to that of a person holding his abdomen with both hands. They are of various patterns and designs; are used in cases of obesity, before and after parturition, and sometimes in cases of umbilical hernia.

Fig 3.



Abdominal Supporter.

Moody's Supporter, 1864, has a corset A, with lacings *c d b* and air-bag B secured by elastic plates *b* to the stays. The pad acts as an elastic truss.

There are various forms, patented and otherwise.

A-bee'. (*Fabric.*) A woven stuff of wool and cotton made in Aleppo.

A-beam'. Opposite the center of the ship's side; as, "the wind is *abeam*."

Ab'e-run'ca-tor. A weeding-machine.

A-bout'-sledge. The largest hammer used by blacksmiths; wielded by the helper, *turn-about* with the smaller hammer of the blacksmith himself.

A-bra'dant. A material, generally in powder, for grinding. The term includes emery, sand, glass, and many other materials. Laps, glazers, rifles, paper, etc. are armed with abradants. See EMERY; and GRINDING AND POLISHING MATERIALS.

A-breu-voir'. (*Architecture.*) The mortar-joint or interstice between two voussoirs of an arch or the stones of a wall.

A'brid. A brushing-plate around a hole in which a pintle works.

Ab-sorb'ing-well. A well or shaft, dug, bored, or driven through a retentive stratum to allow surface or spring water to pass to a porous stratum below the former, so as to form an outlet for drainage.

Such wells are made at discretion in England, but in France are regarded with jealousy, and their use is only permitted after an examination and report by experts as to their possible effect upon watercourses, drainage or irrigation of other properties, etc.

In the United States they are but little used, and are not under public regulation.

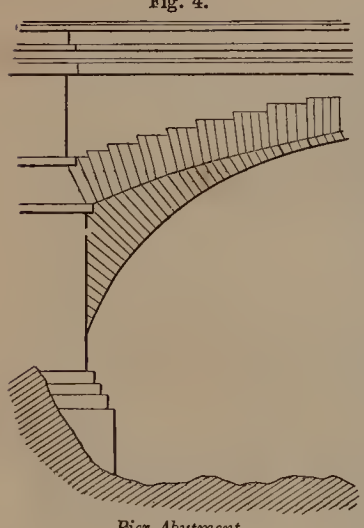
Absorbing-wells are known as *dead wells* in the South of England; they are made in the gravel, the upper portion being close-steened work and the lower open-steened work. The bottom is unpaved, to allow the water to infiltrate.

A-but'ting-joint. (*Carpentry.*) A joint in which the fibers of one piece are perpendicular to those of the other.

(*Machinery.*) A joint in which the pieces meet at a right angle.

A-but'ment. A fixed point or surface, affording a relatively immovable object against which a body *abuts* or presses while resisting or moving in the contrary direction. See PIER; SKEWBACK.

Fig. 4.



Pier Abutment.

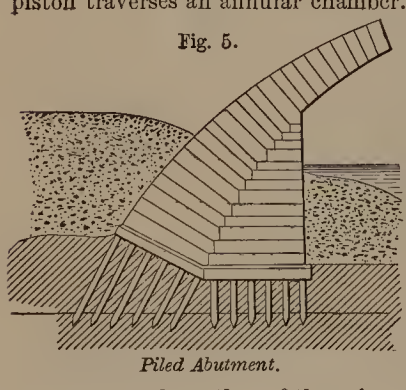
1. (*Building.*) A structure which receives the lateral thrust of an arch. The abutment may be a pier or wing walls forming a horizontal arch; or the arch may be continued to a piled or hewn foundation, which is then the *abutment*.

2. (*Machinery.*) A solid or stationary surface against which a fluid reacts.

a. The wedge which lifts the piston of one form of rotary steam-engine, and which forms a surface for the steam to react against as it presses the piston forward in its circular path.

b. The wedge block in a rotary pump, where the piston traverses an annular chamber.

Fig. 5.

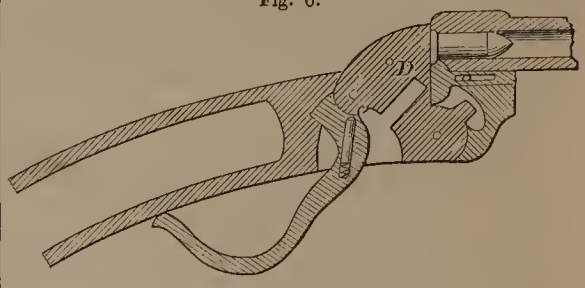


Piled Abutment.

c. One of the cylinder heads of a steam-engine, receiving the back pressure of the steam which is made effective upon the piston.

3. (*Carpentry.*) The junction of two pieces of timber, where the grain of one is at a right angle to that of the other, or nearly so.

Fig. 6.

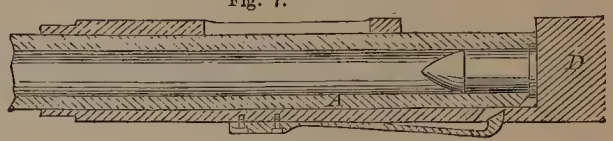


Movable Abutment.

4. (*Fire-arms.*) The block at the rear of the barrel of a fire-arm (especially a breech-loader), which receives the rearward force of the charge in firing.

It has the function of the *breech-plug* or *breech-pin* in the muzzle-loading fire-arm.

Fig. 7.



Stationary Abutment.

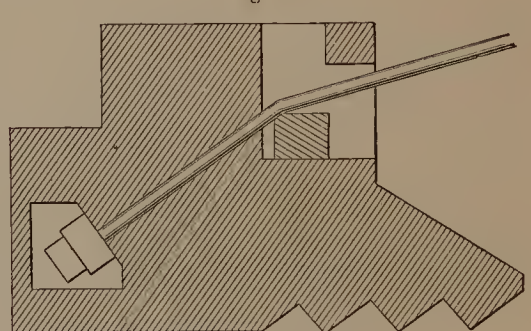
A similar term is applied to the corresponding portion in breech-loading cannon.

In Fig. 6, the *abutment* D is movable upon an axis so as to expose the rear of the bore for the insertion of the cartridge.

In Fig. 7, the *abutment* D is stationary, relatively to the stock, and the barrel slips away from the abutment to allow the insertion of the cartridge. The variations in the arrangement are very numerous, and the different devices form the subjects of numerous patents in the United States and foreign countries. See FIRE-ARM; BREECH-LOADING.

5. (*Suspension Bridge.*) The masonry or natural rock in and to which the ends of a suspension cable are anchored.

Fig 8.



Suspension Bridge Abutment.

6. (*Hydraulic Engineering.*) A dam is in some sense an abutment, as it sustains the lateral thrust of water. See DAM.

A-but'ment Arch. An end arch of a bridge.

A-can'tha-lus; A'can-tha'bo-lus. An instrument for extracting thorns or splinters from a wound.

Ac-cel'er-a'tor. 1. A light van used in England for conveying mails between post-offices and railway-stations, etc.

2. A cannon, with several powder chambers, whose charges are exploded consecutively, in order to give a constantly increasing rate of progression to the projectile as it passes along the bore.

Ac′cent-ed Let′ters. Vowels having signs above them (or below, in the case of the cedilla "ç") to indicate a specific pronunciation ; as : —

Acute,	á	Diæresis,	ä
Grave,	à	Long,	ā
Circumflex,	â	Short,	ă

Ac-cip′i-ter. (*Surgery.*) A bandage applied over the nose ; so called from its likeness to the claw of a hawk.

Ac-com′mo-da′tion Lad′der. (*Nautical.*) A ladder suspended at the side of a vessel to facilitate the passage to and from the boats alongside.

Side ladders and stern ladders hang from these parts of a ship.

Ac-cor′de-on. A *free-reed* instrument introduced into England from Germany about 1828. The exterior form of this instrument is a parallelopiped. The action consists of a bank of vibrating reeds or tongues which are operated by the bellows. Keys open the air-ducts to the respective reeds as the bellows are expanded and contracted. Dampers are attached to the end, which is grasped by the left hand, while the other end is furnished with keys by which the notes are sounded by the fingers of the other hand.

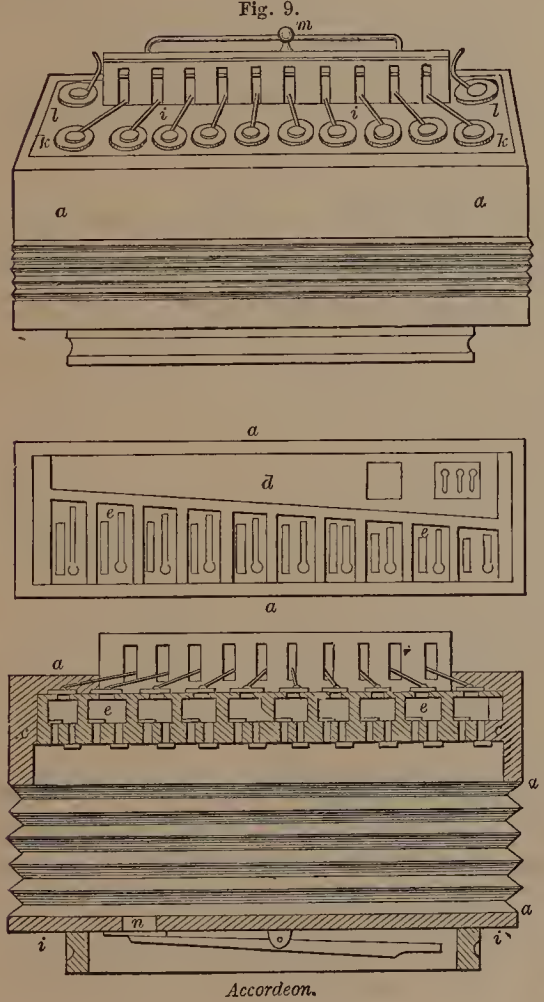
The concertina is an improved form of the accordeon.

A common form of the accordeon is shown in the engraving, which affords three views : —

A general exterior view ;

A sectional view in the plane of the key-board, and exhibiting the separate wind-cells ;

Fig. 9.



Accordeon.

A sectional view at right angles to the latter, and exhibiting the parts concerned in the course of the air, — damper, bellows, ducts, and cells.

a a is a rectangular box, the lower portion of which is of air-tight flexible material forming the bellows and wind-chest ; *c* is a partition forming the top side of the wind-chest, and the lower surface of the large cell *d*, and the ten smaller cells *e e*. In the bottom of each cell are two apertures cut through the partition *c* ; each of these apertures is covered on one side by a thin metallic plate, which has a long rectangular opening in which a free reed plays as the air passes through the opening when the bellows is in action, and the appropriate key is lifted. See FREE REED.

On the side of each aperture, opposite to that occupied by the reed, is a flap or valve of thin leather, cemented by an edge to the partition *c*. The reeds of each cell are fixed one to the upper side of the partition and the other to the lower side ; the reed above the partition is sounded when the bellows is extended, and that below the partition when the bellows is collapsed ; the flap of leather, in each case, prevents the sounding of the reed when the wind goes in a direction contrary to that described.

The large cell *d* has also apertures, which are provided with reeds and valves at the respective ends of the apertures, as just described. The plates of these reeds have two or three tongues of greater size and lower tone, forming a base which chords with the other notes by which the air is played.

The tops of the cells *e e d*, or the partition *c*, are covered with buff leather, against which the under side of the cover *i i* slides when it is pushed into closed position.

In the cover, over each of the small cells, is a hole closed by a key *k*, and over the large cell *d* are two holes, one at each end, closed by the keys *l l*, which are moved simultaneously by the knob *m*. The valve *n*, at the bottom of the wind-chest, forms a damper by which the bellows may be extended or contracted, when required, without sounding a note.

Several notes may be sounded together, and, the reed of each small cell being different, the compass is equal, tones and semi-tones being counted, to the number of reeds.

The accordeon differs from the melodeon more in size and the mode of manipulation than in principle. The latter will be considered by itself, but may be stated to be of such size as to constitute a piece of standing furniture, having its keys in a bank, like a piano, and foot-pedals for the generation of wind, by which the reeds are vibrated as the action of the keys opens the corresponding valves. The same instrument is known in England as the harmonium, and has been known at various times by the names of seraphine, æolophon, symphonium.

FAAS, June 13, 1854, combines, with the diatonic scale of the large keys, two other scales, viz., one for producing all the intermediate notes or semi-tones, and the other founded upon the subdominant of the diatonic scale ; both arranged so as to be fringed by a single set of small keys, to enable the performer to produce harmony in any key. The valves of the lower, or small, keys stop two series of apertures opening from the wind-chest below. The two series of apertures are alternately opened and closed by means of a wind-stop, with two rows of apertures arranged in alternate order. These are governed by levers jointed to the wind-stop and to one another.

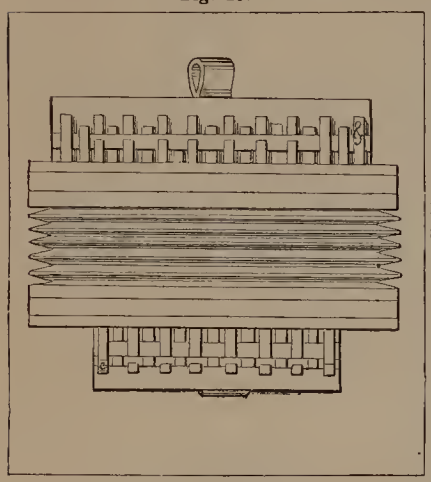
A sounding-board gives strength and resonance to the tones, and allows space for the described arrangement of the valves.

Faas, August 12, 1856. Immediately beneath the perforated board through whose openings the air enters, is a thin sliding board with corresponding apertures. By means of a handle the operator adjusts the position of the board so as to vary the strength of the tones by regulating the quantity of air admitted to the reeds. Double keys close the apertures of the base reeds, the smaller keys covering holes through the larger ones, by which arrangement an entire octave of base notes is produced.

Zimmerman, July 10, 1866, has certain distinguishing keys between the consecutive octaves, which give the same tone in either inflating or compressing the wind-chest.

Pries, June 21, 1864. The accordeon is so constructed as to admit of its being played in any key, to accompany an orchestra; this is accomplished by arranging double keyboards, one on each side of the instrument, which admit the additional number of keys, conveniently arranged for the additional reeds necessary for the purpose. The keys in the respective banks of each end represent octaves, and the respective ends represent different chromatic scales.

Fig. 10.



Pries's Accordeon.

The instrument is called by the inventor an *orchestron*, and the banks of keys are placed at an angle with the side, so as to present the keys more conveniently to the fingers of the performer.

Ac-coup'le-ment. (*Carpentry.*) A timber tie or brace.

Ac-cou'ter-ments. (*Military.*) The devices by which a soldier carries his arms, ammunition, etc. These vary in the different arms of the service, according to the exigencies of the case.

Those for infantry consist of a cartridge-box and plate, cartridge-box belt and plate, waist-belt and plate, gun-sling, bayonet-scabbard, and cap-pouch; to which, on a march, are added the knapsack, canteen, and haversack.

The infantry cartridge-box is made of black bridle-leather, with an outer flap which turns over, covering the top, and is fastened by a short strap to a brass button; inside of this is a lighter leathern cover to protect the ammunition when, as in action, the outer flap is necessarily left unfastened. A brass plate is generally affixed to the flap, but is not essential, being rather ornamental than useful. In the interior of the box are two tins, each having an upper and a lower compartment, the former being divided into two parts, one containing six and the other four loose cartridges, while a bundle of ten is placed in the lower compartment, which is open at the side; the box thus contains forty cartridges when filled. At the side is a small pocket, covered by a flap, for containing the implements, or "appendages," belonging to the musket, as the screw-driver and cone-wrench, wiper, ball-screw, spring-vice, and tumbler-punch.

Two loops are attached to the back for the passage of the cartridge-box belt, which passes diagonally across the body in front and rear from the left shoulder to the right side, where it passes beneath the waist-belt and is secured to the cartridge-box by two buckles. For ornament a round brass plate (in the United States service stamped with an eagle) is attached to this belt so as to fall about the centre of the chest of the wearer. The waist-belt, as its name imports, passes around the waist, and carries the bayonet-scabbard and cap-pouch; it also serves to keep the cartridge-box and belt in place close to the body; it is fastened by a brass plate of oval shape, having two studs and a hook, the studs entering two holes in one end of the belt, which is drawn tight and the hook inserted in a hole at the other end.

The bayonet-scabbard is made of black bridle-leather; it is triangular in shape, to fit the bayonet, and has a brass ferrule at its bottom for ornament and protection; its length is 19½ inches; a leather loop, or *frog*, is attached to the upper part of the scabbard for inserting the waist-belt.

The cap-pouch is also made of black bridle-leather, and has a flap and inner cover, the flap being fastened by a brass button; the pouch is 3 inches in length and depth, and is lined with sheep-skin with the wool on, to prevent the caps from being jarred out and lost when the flap is not buttoned. A cone-pick, of steel wire, bent so as to form a ring at one end, is inserted in a loop in one corner of the cap-pouch.

The gun-sling is of russet bag-leather, 1¼ inches wide and 46 inches long; it has a standing loop at one end and a brass hook at the other, with a sliding loop between. For use it is passed through the guard-bow and middle-band swivels of the musket, the hooked end passed through the loops and inserted in one of a series of holes punched in the sling; the gun may then be slung across the back, leaving both hands free, or it may be suspended from any suitable object.

All belts in the United States land service are black, and are made either of leather or of a strong species of felting, called *buff*, probably because belts were formerly made of that color.

Until within a very few years a separate belt was used for suspending the bayonet-scabbard, passing over the left shoulder and crossing the cartridge-box belt diagonally on the breast, which was ornamented with a plate at the crossing; the intersection of these two white lines, particularly when relieved against the dark-blue ground of the uniform, rendered the soldier as perfect a target as a marksman need desire, the plate representing the "bull's eye."

The cartridge-box belt has sometimes been dispensed with, particularly for riflemen, the whole weight of the accouterments, with, in this case, the addition of a heavy sword-bayonet and scabbard, being borne by the waist-belt, which of course had to be drawn very tight, forcibly compressing the abdomen, and causing great and unnecessary fatigue or even permanent injury.

This arrangement was, we believe, generally condemned by medical men, and in fact by every one who thought on the subject; but as the weapon above mentioned was in very limited use, toward the close of the war especially, the evil was not so general as it might have been.

The cartridge-box for cavalry resembles in external appearance that for the infantry, but is smaller, and its two loops are arranged so as to pass the saber-belt through them. Those used by our troops

during the late war were variously arranged in the interior to suit the supposed necessities of the cartridges of each particular kind of carbine, as Burnside's, Merrill's, etc., etc. That adapted for a paper cartridge, as Sharp's, of which a greater number was issued than of any other, appeared to answer very well for others, though, no doubt, for metallic cartridges a special box is better.

The cavalryman is also provided with a small box or pouch for revolver cartridges and a cap-pouch.

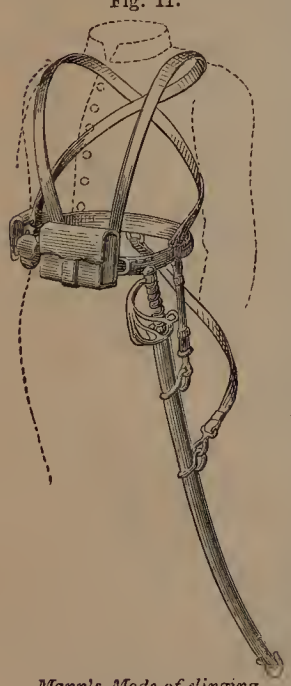
The saber-belt, to which all the preceding are attached, consists of a waist-belt, with two brass rings for the shoulder-strap and saber-slings, and a brass loop sewed at one end to receive the plate, which is rectangular and connects the two ends of the belt together. The shoulder-strap passes from a ring on the left side over the right shoulder, and returns, supporting the saber, which is suspended by two saber-slings passing from the brass ring at the waist-belt through two iron rings on the saber-scabbard, and buttoned.

The accouterments for horse artillery merely consist of a pistol cartridge-pouch and a cap-pouch, both similar to those above described, and a saber-belt which differs from the cavalry-belt only in the omission of the shoulder-strap.

A number of patents have been granted in the United States for improvements in the construction of, and in slinging accouterments. Since the commencement of the late war thirty-five patents have been granted in this branch of inventions. Attention has been directed to several points: —

First. The ease of the soldier in carrying his knapsack, etc. has been attempted to be secured: 1. By making one portion of his accouterments balance another, as in Mann's, Mizner's, and Wood's; 2. By a saddle-piece resting on the hips, as in Dickey's; 3. By suspension-hooks on the shoulders, as in Sweeney's; 4. By a frame reaching from the shoulders to the buttocks, as in Baxter's; 5. By modes of shifting the weight occasionally to vary the point of pressure and relieve the otherwise constant strain, as in Short's and Süs's.

Fig. 11.



Mann's Mode of slinging Accouterments.

Secondly. In arrangements for making the knapsack do service as a shelter, couch, or mattress.

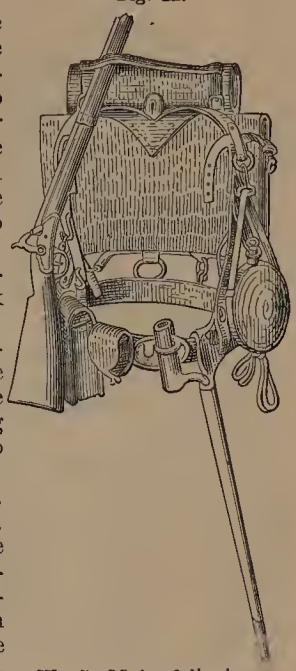
Thirdly. In devices for the more compact arrangement of the compartments of the knapsack, haversack, or cartridge-box to increase their utility, readiness for duty, and lightness.

The accompanying cuts will render it unnecessary to give a lengthened description, and the examples are placed in the order stated, founded on the similarities of purpose and means.

Mann, December 8, 1863. The cartridge-box is worn in front of the person, and acts as a counterbalance to the other accouterments, the weight of the whole being thrown upon the shoulders.

Wood, May 15, 1866. The devices refer to the means for slinging the gun, bayonet, cartridge-box, and canteen so as to counterpoise each other and the knapsack. The gun is hung to hooks on the strap. A hook on the cartridge-box adapts it to be attached to any part of the equipment. The bayonet is also slung by a hook on its scabbard.

Fig. 12.

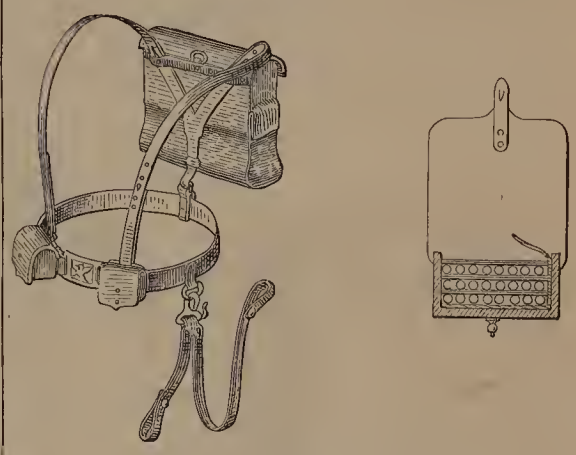


Wood's Mode of slinging Accouterments.

When the accouterments are shifted to the rear, the hind side of the belt is connected to a ring beneath the knapsack, to help sustain the belt.

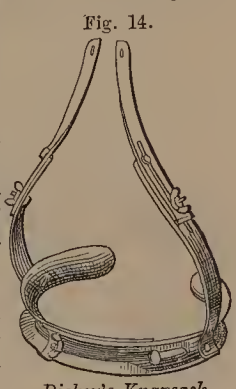
Mizner, January 16, 1866. The haversack, which is carried on the shoulders, forms a counterpoise for the cartridge-boxes, which are worn on the front of the belt; the upper portion of the divisional haversack is occupied by boxes, to contain three days' meat, coffee, sugar, and salt, in separate cases; the lower or bag-like portion being adapted to contain an equivalent quantity of bread. A strap passing along the bottom and up one end of the cartridge-box affords the means for elevating the packages of cartridges, which fit closely therein, and are difficult of removal by the fingers.

Fig. 13.



Mizner's Cavalry Accouterments.

Fig. 14.

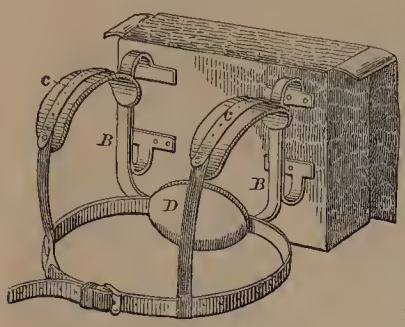


Dickey's Knapsack Supporter.

Dickey, March 21, 1865. To relieve the soldier of the backward pulling of the knapsack it is partially supported by adjustable standards rising from a saddle-piece, which rests upon the hips.

Sweeney, February 4, 1862. The knapsack is so suspended that an air space may intervene between it and the back of the soldier. The curved pads *c* rest upon the shoulder,

Fig. 15.

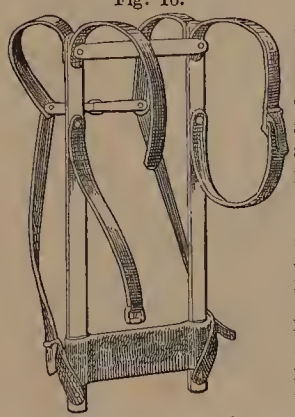


Sweeney's Knapsack.

and the bars *B* descend therefrom to the back plate *D*. The knapsack is secured by plates to these parts, and rigidly held at a distance from the back.

BAXTER, March 17, 1863. This improvement is intended to prevent the pressure of the knapsack upon the small of the back and the cramping of the movement of the arms, and it consists in supporting the sack by strips of wood extending from the shoulder to the hips; also in securing the chest-straps so as to leave the arms free.

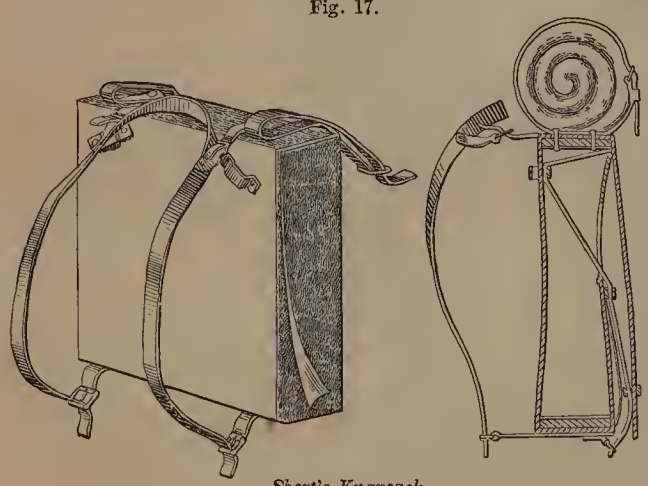
Fig. 16.



Baxter's Knapsack Sling.

SHORT, January 28, 1862; December 14, 1862. The mode of slinging the knapsack permits it to be loosened so as to fall away from the shoulders and spine of the wearer, as a means of shifting the weight and pressure, and allowing circulation of air against the back of the person. The arrangement also permits it to be raised

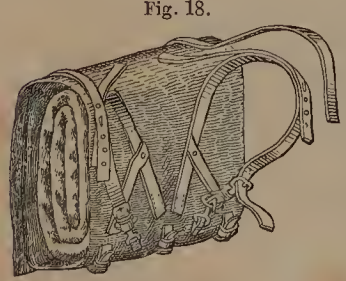
Fig. 17.



Short's Knapsack.

or lowered in a vertical line according to the convenience of the soldier. The neck and shoulder strap is connected to the upper part of the knapsack by intermediate straps, and the lower part of the same is designed to prevent lateral swaying during quick movements.

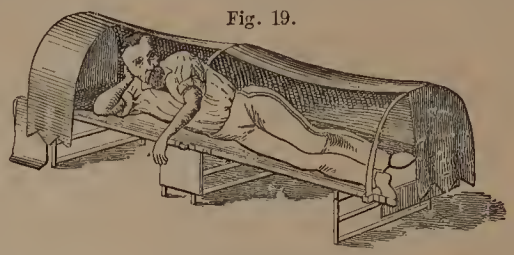
Fig. 18.



Süs's Knapsack.

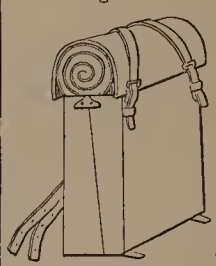
SÜS, May 17, 1864. This invention consists in the employment of a pair of suspending straps which pass over the shoulder in connection with another shorter pair of straps attached to the top of the knapsack near its center, and also a pair of straps attached, one to each end of the knapsack, for the purpose of varying the position and shifting the weight of the same when desirable.

Fig. 19.



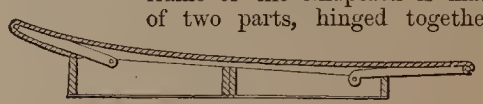
Weber's Knapsack.

Fig. 20.



WEBER, January 31, 1865. The frame of the knapsack is capable of being changed into a couch, and the cover forms a shelter. The central section has jointed and folding sides.

RUSH, March 25, 862. The frame of the knapsack is made of two parts, hinged together.



Rush's Knapsack.

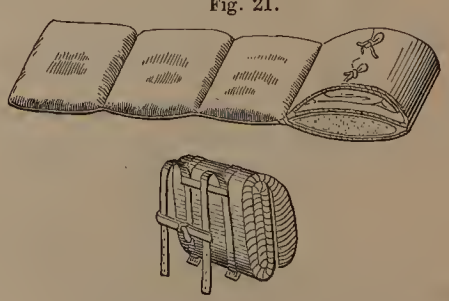
At the thick end of one part are pivoted two arms, which, when thrown out, rest upon the edge of the knapsack, and serve to hold the canvas for forming a bed.

FRODSHAM AND LEVETT, October 1, 1861. This invention consists of an india-rubber casing made water-tight and containing a bag of finely cut cork or other filling, thus forming a life-preserver. A pocket is made in the rubber casing to contain articles of clothing, thus forming a knapsack, which when unrolled becomes a bed, the contained articles forming a pillow.

MIZNER, November 27, 1866. The knapsack is combined with a haversack. The straps that secure the parts of the sack together, when packed and folded, are not sewed to the material, but are riveted to each other, and also to the sling-straps. The latter pass from the knapsack over the shoulders, beneath the armpits, and unite behind the back.

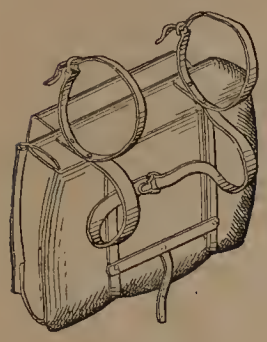
McEVOY, January 7, 1862. The body is

Fig. 21.



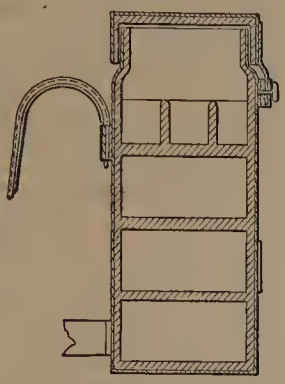
Frodsham and Levett's Knapsack.

Fig. 22.



Mizner's Knapsack.

Fig. 23.

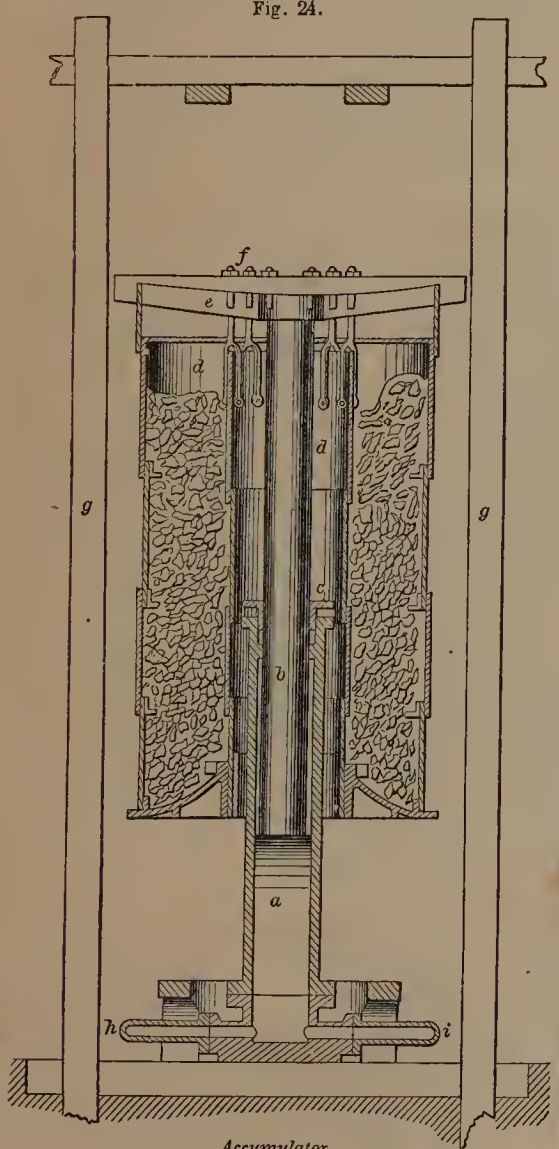


McEvoy's Knapsack.

made of wicker-work, and has partitions and doors; it is covered with waterproof material, and contains medicines, lint, bandages, splints, and surgical instruments. It is designed to be carried by the surgeon's orderly in an engagement or during field duty.

Ac-cu'mu-la'tor. An india-rubber spring which accumulates lifting force, and is applied to many

Fig. 24.



Accumulator.

specific purposes on board ship, in machine-shops, etc.

An apparatus used in working hydraulic cranes and other machines where a steady and powerful pressure of water is required. The accumulator is intended as a substitute for a natural head, as being more compact. Sir William Armstrong, in the first applications he made of this principle to hydraulic cranes, employed a *natural* head of water as the motive agent, obtaining the same by pumping water into tanks at an elevation of about 200 feet; but subsequently he has always employed the *accumulator*, as offering the advantages of greatly increased capacity for pressure, and a less prime cost of erection. The accumulator is shown in Fig. 24; it consists of the large cast-iron cylinder *a*, fitted with the plunger *b*, which works water-tight by means of the gland *c*, and packing. To this plunger is attached, by means of the bolts *f*, and strong cast-iron cross-head *e*, the loaded weight-case *d*. Thus a pressure is obtained upon the water in the cylinder, equal to a column of water 1500 feet high, or 660 lbs. upon the square inch. As the water is pumped into the cylinder by the pumping engines through the pipe *h*, the piston, with the weighted case, rises, being guided by the strong wooden framework *g*, and is made to regulate the amount of water pumped in, by actuating a throttle-valve in the steam-pipe of the pumping engine, which it closes after having reached a certain height. When the cranes, etc. are in operation, the water passes from this cylinder through the pipe *i*, to those actuating the motion of the cranes, and the weighted plunger naturally descends, always keeping up a constant pressure upon the water; in descending, the same causes the throttle-valve to open again, and the water is again pumped in.

A'ces. (*Nautical.*) Hooks for the chains.

A-cet'i-fi-er. An apparatus for exposing cider, wort, or other wash to the air to hasten the acetification of the fermented liquor. See GRADUATOR.

Ac'e-tim'e-ter. See ACIDIMETER.

Ac'e-tom'e-ter. A hydrometer suitably graduated for ascertaining the strength of acetic acid and vinegar.

Ach'ro-mat'ic Con-dens'er. An achromatic lens or combination used to concentrate rays upon an object in a microscope. See *Carpenter on the Microscope*, pp. 117–119, ed. 1857.

Ach'ro-mat'ic Lens. Achromatic, literally colorless, lenses were first introduced by John Dollond, of London, about the year 1758. Ever since the invention of the telescope it had been a desideratum with astronomers and opticians to obtain a lens which would give a perfect image free from color with a moderate focal length, it having been found by experience that it was necessary to increase the length of focus of the object-glasses of telescopes in the proportion of the square of the magnifying power desired, to obtain distinct vision. This was owing in part to the distortion or spherical aberration, caused by the rays striking the lens at greater or less distances from its center, being refracted at different angles in proportion to the greater or less convexity of the lens, and converging to different foci more or less distant from the latter; but principally to the dispersion or decomposition of the light, as in prisms, to two of which, joined at their bases, the lens is in fact equivalent. See PRISM.

This fringed or colored appearance may be observed about the margin of almost any object viewed through a lens of short focal length, such as an ordinary microscope.

The excessive length which had to be given to re

fracting telescopes in order to obtain what is now considered a very moderate magnifying power, 100 feet for a power of 200, led Gregory and Newton to the construction of reflecting telescopes (see TELESCOPE), and these for many years were almost the only kind in use. The dispersion of light, or the length of the spectrum formed by prisms having the same refracting angle, varies greatly in different substances though their refracting powers may be equal or nearly so.

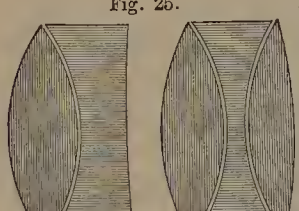
Newton had supposed that the dispersion was always proportional to the refraction, and it was in the course of a series of experiments undertaken in order to verify this theory of Newton, which had been controverted, that Dollond was led to his discovery.

He found that a prism of white flint glass whose refracting angle was about 25 degrees refracted the light in a nearly equal degree with one of crown glass whose refracting angle was 29 degrees, but that the dispersive power of the former was much greater; so that, when they were applied together to refract contrary ways, a beam of light passed through them was separated into its component colors, although the incident and emergent parts of the beam continued parallel.

From this he inferred that if two lenses, one convex and the other concave, — which are in effect equivalent to two prisms refracting in different ways, — were so arranged as that the dispersive power of the flint glass would be corrected by the crown glass, that the image produced by the excess of refraction of the latter would be sufficiently colorless and distinct to bear an eye-glass of much shorter focal length and consequent magnifying power than could be applied to a non-achromatic, double-convex lens, formed of a single piece of glass; and by further experiment he ascertained the most advantageous focal lengths to be given to each glass in order to produce clearness and distinctness.

He adopted a combination of three lenses, the middle one being of flint glass and double concave, and the two exterior ones of crown glass, double convex, believing that it produced better results and more effectually corrected the spherical aberration; the combination of two glasses is now, however, universally adopted.

Fig. 25.



Achromatic Lenses.

It has been proposed to use metallic solutions and other liquids which have a higher dispersive power than flint glass, enclosed in glass disks of the proper curvature hermetically sealed at their edges, in place of that article for the concave lens, but though several of these substances appear to have given excellent results experimentally, they have never been brought into general use.

On account of the difficulty of obtaining a good article of flint glass, more particularly, and the trouble and skill required in grinding and polishing the faces of each piece so that they may have the proper curvature and fit accurately together, achromatic lenses have always been and will probably continue to be very expensive, especially the larger sizes. Dr. Dick mentions one of $5\frac{1}{2}$ inches aperture and $5\frac{1}{2}$ feet focal length, which cost 200 guineas.

Plöpl, an optician of Vienna, has recently invented an improvement on the achromatic, which he calls the dialytic telescope, in which the several different kinds of glass composing the compound object-glass are not placed close together, but at regulated distances apart. This arrangement allows a shortening of the tube.

Chester More Hall, of Essex, England, invented the achromatic telescope in 1729, but did not make it public. Dollond had to invent it over again.

Ac'id-im'e-ter. An instrument for determining the purity or strength of acids, founded on the principle that the strength of any sample of acid is proportionate to the quantity of alkali which it will neutralize, or the quantity of carbonic acid gas which it disengages from a carbonate of soda or potash. An accurate and economical apparatus for this purpose is proposed by Dr. Ure, as follows: a graduated glass cylinder, having a discharge tube and capable of containing 10,000 grains of distilled water, is attached by a flexible tube to a Florence flask containing a supersaturated solution of carbonate of soda or potash, in which is a test-tube containing a sufficient proportion of acid by weight to evolve carbonic acid gas equal in volume to the contents of the cylinder. Bicarbonate of soda is preferred, as one equivalent of any acid disengages from it two equivalents of carbonic acid gas, and the quantities of various acids required to evolve a volume of gas equal to 10,000 grains of distilled water are as follows: —

Anhydrous sulphuric acid,	16.80	grains.
Oil of vitriol,	20.58	"
Anhydrous nitric acid,	22.67	"
" hydrochloric acid,	15.33	"
" acetic acid,	21.42	"
Crystallized citric acid,	80.64	"
" tartaric acid,	63.00	"

By tilting the flask the test-tube is upset and the acid brought in contact with the alkaline solution, liberating the carbonic acid gas, which passes over into the cylinder, displacing a bulk of water equal to that of the gas evolved, the amount of which is shown by the graduations on the side of the cylinder. This indicates the strength of the acid. For example, if the water should be depressed to the mark 50 on the cylinder, it shows that the sample contains but fifty per cent of pure acid. This apparatus is the converse of the *alkalimeter*, which see.

A-cis'cu-lis. A small mason's pick, with a flat face and pointed peen.

A-cock'bill. 1. The situation of the yards when they are topped up, at an angle with the deck.

2. The situation of an anchor when it hangs from the cat-head by the ring only.

A-cou'me-ter. An instrument invented by Itard for measuring the degree or extent of hearing.

A-cous'tic In'stru-ments. Instruments or apparatus pertaining to the ears, the perception, measurement, or projection of sound.

I. Those appertaining to the ear are, — 1. *Prosthetic.* 2. For *exploration.* 3. For *operation.*

1. Of the *prosthetic* are the
   - Auricle.
   - Cane Trumpet.
   - Cornet.
   - Conversation Tube.
   - Ear; Artificial.
   - Ear of Dionysius.
   - Ear Trumpet.
   - Sonifer.
   - Tympanum; Artificial.
2. *Exploration.*
   - Acoumeter.
   - Ear Speculum.
   - Otoscope.

3. *Operation.*
Ear Spoon.
Ear Syringe.
Eustachian Tube Instrument.
Meatus Knife.
Organic Vibrator.

II. Instruments for making or conveying audible sounds.

(Not including those of a prosthetic nature cited in Class I.)

Acoustic Telegraph.
Air pipe.
Alarms. (*Varieties;* see ALARMS.)
Musical Instruments. (*Varieties*, see MUSICAL INSTRUMENTS.)
Speaking Trumpet.
Speaking Tube.
Steam Whistle.

III. Instruments for measuring the quality of sound, the extent of hearing, the number of vibrations in a given time, etc.

Acoumeter.
Kaleidophone.
Metronome.
Sirene.
Sonometer.
Tonometer.

IV. Auscultation Instruments.

Percussor.
Pleximeter.
Stethometer.
Stethoscope.

(See the above in their alphabetical order.)

A-cous'tic Tel'e-graph. A telegraph making audible iustead of visual signals.

In this sense — the most general — every *sounder* may be included in the class, for it is capable of being, and is, used to convey information by an arrangement of repetitive blows and intervals.

The present common use of the Morse instrument brings it within this category, the siguals being read by ear rather than by consulting the paper ribbon.

The speaking-tube may be considered another form, conducting a puff of air to the other end, where it operates a whistle, or the sound is recognizable as an audible expression.

Bright's (English Patent) is adapted to communicate phonetic siguals. It consists of au axle having a magnet and double arm; the magnet, when acted upon by electro-magnetic coils, causes the axle to vibrate or deflect in one direction, thus sounding a bell by means of a hammer-head on one arm; the subsequent reversal of the electric current causes a muffler on the other arm to stop the sound.

In a more perfect form, Bright's Acoustic Telegraph consists of a hammer in connection with a lever, which is acted upon by every polarization of a set of electro-magnets by the local current, and thereupon strikes a small bell. A pair of these bells are connected to each wire; one bell is struck by the passage of the positive, and the other of the negative current, the alphabet being readily formed by the difference in their tones and the number of beats.

Another form of audible telegraph consists of a wire which is tapped and conducts the sound to a resonant diaphragm.

Wilson's Patents, 1866, refer to the production of a musical note by the action of a valve governed by the electro-magnetic current. The sound is continuous or intermittent, and variable in tone or pitch, as may be required.

Ac'ro-ter. A small pedestal placed on a pediment and serving to support a statue

Ac-tin'o-graph. An instrument for registering the variation of the chemical intensity of the sun's rays. As contrived by Mr. Hunt, it consists of a fixed cylinder on which is placed a prepared photographic paper covered by a revolving cylinder having a triangular opening divided by bars through which the direct rays of the sun pass; their effect upon the paper indicates their chemical intensity at different times.

Ac'ti-nom'e-ter. An instrument for measuring the power of the sun's rays, invented by Sir J. F. W. Herschel about 1825. A hollow cylinder of glass filled with a colored liquid is soldered to a thermometer-tube blown into a ball at the upper end; being exposed alternately to the sun's rays and removed to the shade, a comparison of the differences of expansion of the liquid indicates the relative intensity of the solar radiation.

The discovery of the presence of another principle, associated with the light and heat derived from the sun, seems to have been made some years ago by Mr. R. Hunt in England.

Sir J. Herschel proposed to establish, as a unit for the intensity of solar heat, that value which would, in a minute of time, dissolve a thickness equal to one-millionth part of a meter of a horizontal sheet of ice, when the sun's light falls vertically upon it. This he calls an *actine*, and from experiments made by him at the Cape of Good Hope he determined the value of a degree on the scale of one of his *actinometers* to be equivalent to 6.093 *actines*.

The actinometer is useful in determining the quantity of solar heat which is absorbed in passing through the different strata of the atmosphere, for which purpose the observations must be made at stations differently elevated above the level of the earth or sea. It may also be employed to determine the diminution of heat which takes place during eclipses of the sun.

See *Manual of Scientific Inquiry*, published by the English Board of Admiralty.

One form of *actinometer* is sometimes called a photometer. The former name indicates that its purpose is to determine the *actinic* power of the solar rays, while the latter name indicates a measurer of the *intensity* of the light.

One use of the actinometer is to ascertain the proper time for exposing a plate in the camera, or a sensitized paper in the printing-frame. The box has a spring bottom and a glass and wooden cover. On the under side of the glass are secured a series of thin strips of paper arranged in layers so that each layer projects over the edge of the strip above it, thus producing a graduated semi-transparent medium. The number of layers of any particular point is indicated by black figures on the lowest strips of paper. Upon this false bottom is spread a series of strips of paper rendered sensitive by saturating with alkaline chromate. The apparatus is then exposed to the light, and the strips of sensitive paper will be successively darkened according to the depth of over-lying paper. See PHOTOMETER.

Ac'tion. An exertion, applied in machinery to an effective motion; as, —

A *single* action; illustrated in the ordinary lift-pump, the atmospheric engine, etc.

A *double* action, in which the go and return motions are each made effective or are positively effected by the motor: as the double-acting pump, throwing a stream at each course of the piston; the ordinary high-pressure steam-engine, in which the piston is driven each way by the force of stream.

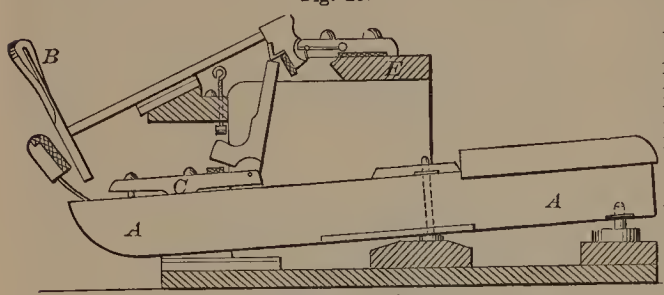
(*Music.*) The *movements* or working parts of a stringed or wind instrument, which is operated by

a key-board; such as an organ, piano-forte, melodeon, etc.

It includes the portion between the keys and the strings, — the portion engaged in *striking* and *damping*.

The *actions* are known, by a peculiarity in the instrument, as *grand*, *square*, *piccolo*, *single*, *double*, *upright* actions; or from the inventors, as Broadwood's, Collard's, Erard's, Steinway's, etc. See PIANO-FORTE.

Fig. 26.



Piano-Forte Action.

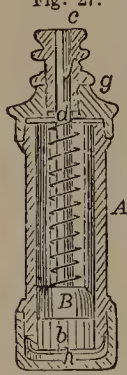
A is the key; *B*, the hammer which falls back upon the *check*, and a bar mid length of the stock, called the *hammer-rail*. *C* is an adjustable bar on which is mounted the *jack*, whereby the hammer is actuated. *E* is the rail to which the hammer is hinged.

Ac'u-punct'u-ra'tor. Derived from *acus* (Lat.), a needle. An acicular instrument for treating certain complaints, such as headaches, lethargies, etc. It is of great antiquity in the East, and of late years it has been introduced somewhat extensively into Europe and the United States. The essential apparatus employed is simply a set of needles set in a handle, or detached needles, which by a slight rotary movement are passed to the required depth beneath the tissues and allowed to remain for a length of time varying from a few minutes to an hour.

In the sixteenth century, according to Jerome Cardan, the practitioners of this art travelled from place to place, and rubbed their needles with a magnet or substance which they pretended rendered their insertion painless. Without any such application, however, the punctures are so minute that pain is not felt after the first insertion of the needle.

The needles are sometimes used for conducting the galvanic current to parts at some distance beneath the surface of the skin, and are sometimes made hollow for the injection of a sedative into the tissues, for the relief of neuralgic affections. This latter mode of application was suggested by Dr. Alexander Wood of Edinburgh, Scotland. See ANÆSTHETIC APPARATUS.

Fig. 27.



Klee's Acupuncturator.

It is sometimes called a *Dermopathic* or *Irritation Instrument*, and is used to introduce a vesicatory liquid beneath the epidermis.

FIRMENICH'S instrument, March 18, 1862, may be considered a type of its class. The piston containing the needles is adjustable in its cylinder, which holds the medicinal preparation. The needles project through the diaphragm to the required extent, and the epispastic liquid insinuates itself along with the needles into the punctures.

KLEE'S acupuncturator, June 19, 1866, has a regulating nut *g*, to adjust the depth of penetration of the needles which project through the diaphragm to conduct the liquid from the cylinder *A* and introduce it through the skin. The needles *b* are stocked in the piston *B*, whose stem *d* is sleeved in the stem-screw *c f*.

In Oriental countries the needles are made of gold or silver. In China their manufacture is regulated by law. They are of different sizes, some about four inches in length and having spiral handles to facilitate their rotation after insertion. They are driven in by a small, lead-loaded hammer with a leathern face. Their use is very common in China and Japan, and was communicated to Europe by the physician to the Dutch Embassy in the seventeenth century. It was revived in France in 1810. The English needles are long, made of steel, and have knobbed heads to facilitate turning after introduction. The tendency here, judging by the patents, is to have the needles in clusters.

The operation is well performed by a tubular needle connected with a syringe, by which a weak solution of morphia is injected into a diseased tissue, producing local anæsthesia. See ANÆSTHETIC INSTRUMENTS; HYPODERMIC SYRINGE. For the reverse use of hollow needles, see TROCAR.

A'cus. A needle. As, —

Acus Cannulata; a trocar, or tubular needle for discharging liquids.

Acus Interpunctoria; a couching-needle used in operations for cataract.

Acus Ophthalmica; one used in operations for ophthalmia or cataract.

Acus Triquetra; a trocar, or three-sided needle.

Ac'u-ten-ac'u-lum. A needle-holder or forceps; a needle-handle; a *porte-aiguille*.

A-dapt'er. 1. A glass-tube open at both ends, and used to connect a retort with its receiver.

2. A receiver with two opposite necks, one of which admits the neck of the retort while the other is joined to another receiver. It is used in distillations to give more space to elastic vapors or to increase the length of the neck of a retort. See ALUDEL.

3. A tube to adapt or fit an accessory apparatus to the body of the microscope, as the adapter which carries the analyzer of the polarizing apparatus, etc.

Ad'a-tis. A species of fine cotton cloth made in India.

Ad-den'dum. (*Gearing.*) The difference between the *real* and the *geometrical* radius of a circular cog-wheel; that is, between the radius of the *pitch circle* and the outer circle which touches the crests of the teeth.

Ad'dice. The obsolete name of an adze; which see.

Add'ing Ma-chine'. An instrument or machine by which adding of numbers is effected. See ABACUS; ARITHMOMETER.

Ad-dress'ing Ma-chine'. A machine for addressing newspapers and magazines in which the same series of names is repeated from time to time as the day of issue recurs. There are two modes. One is to print the addresses consecutively upon slips which are gummed on the back and fed intermittingly to the cutter which cuts off each address. This is then pressed upon the folded paper or pamphlet, which is placed in position to receive its direction. The other mode is to set up the type of each address in a form, and so arrange the forms that they are successively presented at a spot to which the enveloped papers are consecutively fed.

Over twenty patents have been granted in the United States on machines for this purpose.

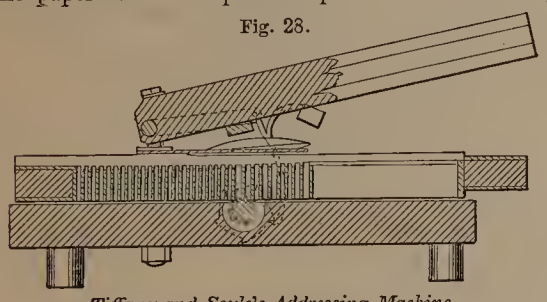
One of the earlier forms of this device is that de-

scribed in MOESER'S patent, June 24, 1851. The different addresses are set up in columns in a galley, and are brought under the action of a stamp, being moved intermittingly by means of a slide; the addresses are exposed *seriatim* at a slit in a plate, allowing the paper or object to be printed to be pressed down upon the address beneath the slit of the plate, and shielding the paper from the adjoining lines. This series of addresses forms a mechanical record on which changes may be made as they become necessary. This patent was reissued January 30, 1866, and was extended to the year 1872.

CAMPBELL, January 20, 1863. The addresses are set up in parallel columns, and are secured in a common chase. The machine is supported over the chase by end-pieces, and is automatically advanced after each depression of the platen. Resting upon ways which span the chase is a traversing bed-piece with an upright, affording a pivotal attachment for a lever which alternately elevates and depresses a platen on the guide-rod. The elevation of the lever, by means of the toggle, actuates the wheel, which, mashing into a rack, advances the platen to deliver another impression on an advanced point. After exhausting all the addresses in a given column, the bed-piece is moved laterally to bring the platen into correspondence with the next column. A paper is fed beneath the platen just previous to the down stroke of the lever. The form is previously inked so that each address is ready to deliver its impression when called on.

TIFFANY AND SOULE, March 20, 1860. The type addresses are contained in a partitional galley or chase, which is moved by a pawl dependent from the platen lever, as the latter is raised. A pinion on the shaft, whose ratchet is thus actuated by the lever-pawl, is the means of forwarding the galley, a cog at a time, and each line of type as it comes to the wide pinion is separated from the rest by elevation so as to expose it at the slit in the plate above, in contact with the paper which is placed upon it below the descending platen. A sheet metal plate depresses the type after the impression is delivered.

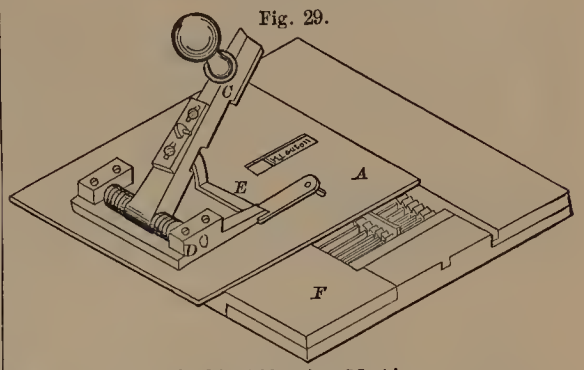
Fig. 28.



Tiffany and Soule's Addressing Machine.

SOULE, October 2, 1860. The forms of the addresses are arranged in columns in the chase *F*, and the plate moves intermittingly above it. The oscillating platen *C* is pivoted to bearings *D*, on the plate *A*, which has a slit brought into correspondence with each address in turn. The plate is advanced intermittingly, after each impression, by the contact of the descending lever with an oblique end to one arm of the bell-crank which is pivoted to the plate, the other end of the lever engaging a rack on the bed-plate.

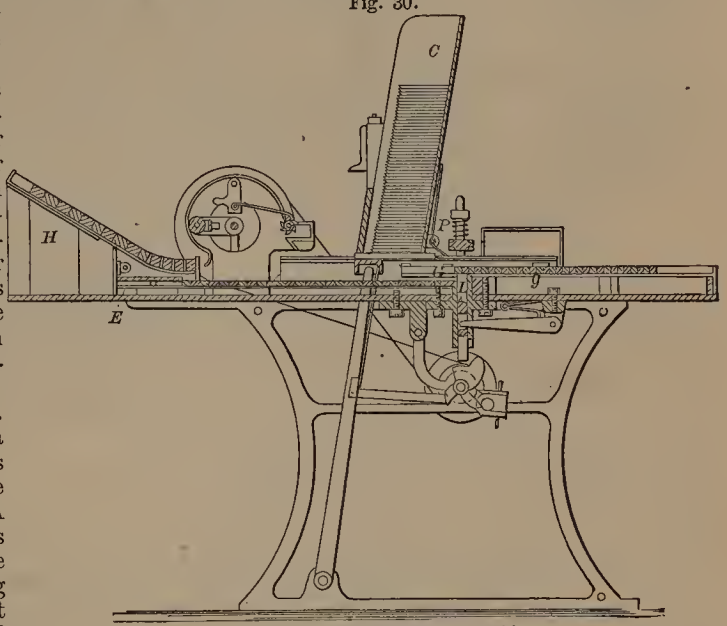
Fig. 29.



Soule's Addressing Machine.

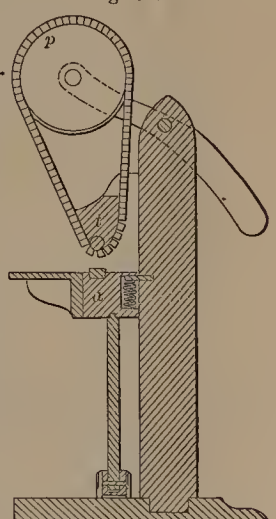
SCHUH, April 26, 1859. The hopper *C* contains the documents, which are discharged consecutively by the movements of a sliding gate which is provided with a heel or step which drives the document before it from beneath the pile. The type addresses are fed down an inclined board *H*, and thence are forwarded along a level channel *E*, to the point beneath the platen *P*. On arriving at this point they are successively raised by the action of a piston *L*, which is raised by a cam on a horizontal shaft beneath. The address is elevated to meet the descending platen *P*, and the paper introduced between them receives the pressure from one and the impression from the other. The type is then forwarded by the type-shifter *G*, along the elevated channel *g*, from whence the addresses are removed in gangs. The notice-bell *R* is actuated by the type at intervals to announce that a certain galley is exhausted.

Fig. 30.



Schuh's Addressing Machine.

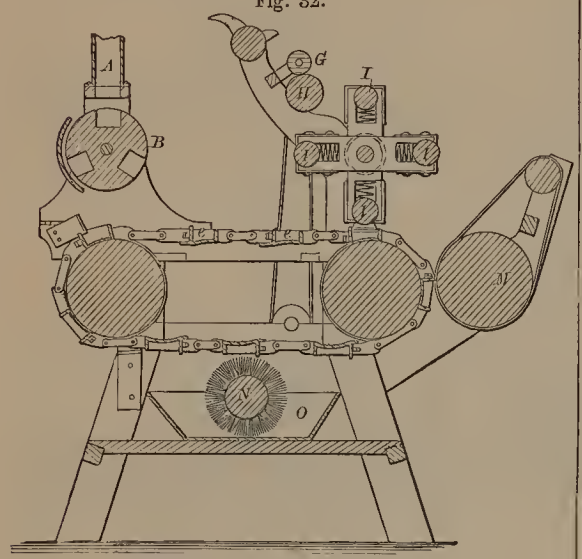
Fig. 31.



Davis's Addressing Machine.

DAVIS, September 6, 1859. The blocks *r* on which the addresses are cut or placed are attached in compact column, but independently, to a flexible band which runs over two rollers *p t*, the lower one, *t*, being of small diameter so as to cause the outer edges of the blocks to separate at the lowest point of their revolution, as seen in the figure. By this separation the lowest block for the time being is distinctly presented to the paper or envelope which is placed beneath it, and raised to the type by the treadle which raises the table *a*.

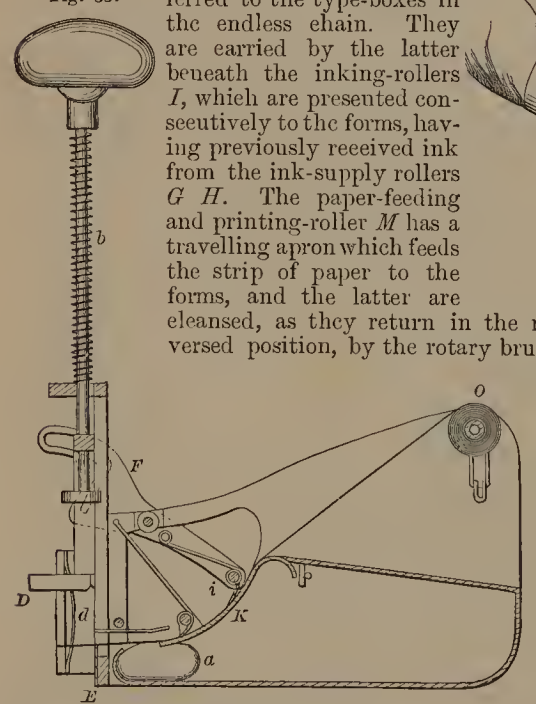
Fig. 32.



Bowlus's Addressing Machine.

BOWLUS, May 1, 1860. The endless chain has type-boxes *e*, which have spring sides for clasping the forms, each of which constitutes an address. The forms are placed in a column in the feed-box *A*, are taken one at a time by the pockets in the feed-wheel *B*, and are transferred to the type-boxes in the endless chain. They are carried by the latter beneath the inking-rollers *I*, which are presented consecutively to the forms, having previously received ink from the ink-supply rollers *G H*. The paper-feeding and printing-roller *M* has a travelling apron which feeds the strip of paper to the forms, and the latter are cleansed, as they return in the reversed position, by the rotary brush *N*, which rotates in the wash-tub *O*, and in contact with the type.

Fig. 33.



Doty's Addressing Machine.

DOTY, January 26, 1864. This machine is for cutting off addresses from a strip of paper previously printed and gummed on the respective sides. The strip is fed from a spool *O*, and is drawn over the concave bed *K* by the oscillating arm *F*, whose finger *i* engages the paper. The gummed side of the paper being underneath is moistened by the wet sponge *a*, and passes between the stationary cutter *E* and the descending cutter *D*, which is depressed by the spring plunger *b*, and so actuated by the spring *d* as to make a shear-cut upon the strip of paper as it removes the address. The feed levers *F* are pivoted to the frame, and actuated by projections from the descending plunger.

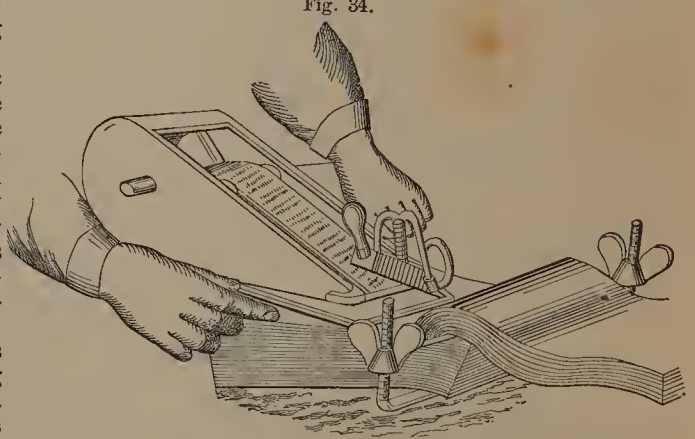
In DICK'S machine, October 4, 1859, the addresses are set up in columns in a form, and the printed sheet is cut into strips, each of which has a column of addresses. The reverse side is pasted, and the slip is fed forward one address at a time; the descending stamp-shear removes the address and presses it upon the wrapper or the paper, as the case may be. The pressure of the machine on the pile of wrappers operates the cutter and removes the label.

In PECK AND WRIGHT'S machine, January 12, 1864, the wooden blocks upon which the addresses are cut are bevelled upon one side, so that a series of them, when placed in a column galley, forms a continuous ratchet, of which each block is a separate tooth by which they are fed forward, preserving the requisite intervals.

In some cases the quads of the forms afford teeth by which the column is advanced.

BARRINGTON, June 14, 1859. The cylinder has

Fig. 34.



Dick's Addressing Machine.

grooved ribs for holding forms of type and presenting them consecutively at the proper point for delivering an impression.

MARSHALL, November 1, 1859. The "forms" constitute links of an endless chain, which unwinds from one drum and winds on to another, being inked on their passage by one set of devices, and the consecutive links depressed by a stamp on reaching a certain point of their progress at which is presented the paper or envelope to be superscribed.

NORDYKE, March 1, 1859. The envelopes on an endless conveyer are fed beneath the forms which are fed upon one track and discharged upon another, being subjected at a given point to the action of a pressure-roller.

CARPENTER, May 5, 1857. The forms are placed in pockets in the periphery of a wheel. The news-

paper being held above the form, the platen is depressed by a treadle and the impression obtained. On releasing the treadle the spring raises the platen, and the pawl turns the cylinder one tooth, bringing the next name in series beneath the platen.

CAMPBELL, January 17, 1860, patented a machine for printing addresses on the margins of newspapers, simultaneously with the printing of the newspapers, by means of cells or boxes, containing the addresses set up in type and conveyed to the form by means of an endless apron having an automatic, intermittent movement.

BATLEY, January 17, 1860. The type are arranged on slats, so connected together as to be moved successively through the machine. The papers are fed into the machine by finger bars and spurs, and the addresses elevated in succession to make the impression.

LORD, September 7, 1858. The type forming the addresses are inserted in boxes secured spirally on the periphery of a revolving cylinder. The newspapers or envelopes are successively pressed against the type in the boxes by a horizontally reciprocating platen whose action is in concert with the cylinder. The inking apparatus is caused to follow the spiral arrangement of the form, being gradually moved by a screw similar to a lathe-feed screw.

HARRILD'S machine (English) consists of a sliding groove of some length, in which is placed a galley containing as many of the required directions as it will hold set up in type and locked up. A treadle moves it along, one notch at a time, under a parchment frisket, till a direction arrives just under the aperture cut in the frisket, the newspaper envelope is laid over it, and the treadle brings a platen down upon the newspaper.

The galley then passes along, notch by notch, till its directions are exhausted, when it is superseded by another.

Ad-he'sion Car. A car whose wheels are adapted to grasp a rail or to bear upon it in such a way as to have an adhesive or tractive power greater than that due merely to the weight of imposition.

Among the forms may be mentioned : —

The *cogged rail*. See RAILROAD.

The *center rail*, with a horizontal pair of gripping-wheels. See RAILROAD ; CENTER RAIL.

Another form is a wheel with an angularly grooved periphery, which bites the flanges of a double-headed rail.

In the early history of railroad engineering many devices, especially the cogged rail, were employed to give adhesion, or tractive grip upon the rail. These were eventually laid aside as more correct views were attained. In climbing inclined planes, however, devices of this kind are yet found useful, and are noticed under the appropriate heads, cited above.

Coefficients of Adhesion of Locomotives per Ton upon the Driving-Wheels.

	Lbs.
When the rails are very dry, . .	670
When the rails are very wet, .	600
In misty weather, ...	350
In frost or snow, ...	200

In coupled engines the adhesion is due to the load upon all the wheels coupled to the drivers.

The adhesion must exceed the traction of an engine upon the rails, otherwise the wheels will slip.

Ad'it. A *drift*, or nearly horizontal tunnel forming a road or drain in a mine, by which the ore is extracted or water carried off. Its discharging end is at the natural surface. A *day-level*, or *sough*.

The great adit in Cornwall drains the waters from the Gwennap and Redruth mines, and is nearly thirty miles long. It discharges its waters into the sea, forty feet above high-water mark.

Adits may be driven either along the course of a vein or bed or through an unproductive stratum of rock, and are frequently run in a direction transverse to the general bearings of the veins or lodes, with a view to exploration ; such an adit is termed a *cross cut*.

In the early working of a mine, the adit, from motives of economy, is made as short as practicable ; but as the operations progress it is often advisable to drive another at a lower level and of greater length, to avoid the difficulty of pumping or lifting the water from a considerable depth.

Ad-just'ing Screw. A set-screw of an instrument by which one part is moved upon another, either for focus, level, tension, or otherwise.

Ad-just'ing Tool. (*Horology.*) A tool by which the snail of the fusee is regulated so that its increase of diameter may exactly countervail the decreased strength of the spring as it unwinds in the barrel. The object is to obtain an exactly equal power at all times upon the train.

Ad'mi-ral. A leading ship of a squadron. (From Sar. *Emir*, the Sea.)

> "To be the mast
> Of some great ammiral." — *Paradise Lost*, B. I.

A-do'be. Adobes, or unburnt bricks, are principally in vogue in the plains of Shinar and Egypt, and in China and certain portions of North America inhabited by the Puebla Indians. If well *burned*, the clay forever loses its plasticity, and cannot again be reduced to a mortar. If it be merely *dried*, it will assume its original condition, as it came from the pug-mill. Such has lately (1871) been the experience of the Chinese in the vicinity of the Hoang-ho, whose houses of adobes are reduced to mud-heaps by the overflow of the river. Mr. Tomlinson, C. E., of London, has treated this matter more fully than any other author writing in our language, and he says : "The first action of heat is to drive off hygrometric water ; the clay then becomes dry, but is not chemically changed, it does not cease to be plastic. On continuing to raise the heat, the chemically combined water is separated, and the clay undergoes a molecular change which prevents it from taking up water again except mechanically. With the loss of this chemically combined water clay ceases to be plastic."

In the directions which have been published for building with adobes, it is recommended that they should be guarded, by some material impervious to water, from absorbing moisture from the ground, and also that the roof should be made to project not less than two feet in order to shed the water and prevent its running down the walls. These directions seem to indicate the weak point, and the experiences derived from the dry plains of Asia and Africa, and the elevated arid regions of Northern Mexico and Lower California, do not apply so well to our more humid climate.

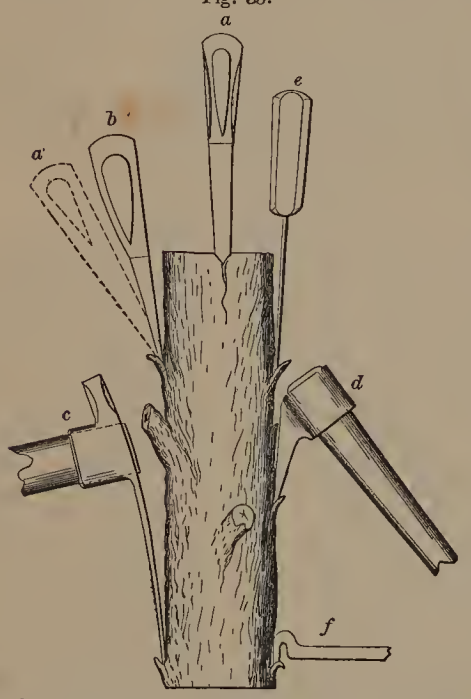
The mold for making adobes resembles the ordinary brick-mold in having four sides and having handles at the ends, but no top or bottom. It is much larger, however, and sometimes a pair are placed in a single frame. It is placed in position on the drying-ground, filled with clay, and when the top is smoothed by a striker, the mold is carefully raised, leaving the adobe to dry for a few days, when it is turned to expose the other side. A few weeks of

favorable weather complete the drying. It is a cheap material and easily built up. It does not appear likely ever to become a favorite mode of building in those parts of the United States which are at present most thickly populated. It will not do to make too general a statement in a country whose climate varies between Alaska and Mexico.

Ad-vice'-boat. A fast-sailing vessel used for reconnoitering. First used, say the authorities, in spying the operations of the French fleet in Brest, previous to the battle of La Hogue, 1692. Of course Themistocles and the consul Caius Duilius never had any light amphiproræ to "overhaul" the Persians or the Carthaginians, "and when found make note on."

Adze. The adze is a very ancient tool, and has a curved blade whose edge is at right angles to the handle; differing from the axe, in which the blade is parallel to the handle. The forms and sizes differ

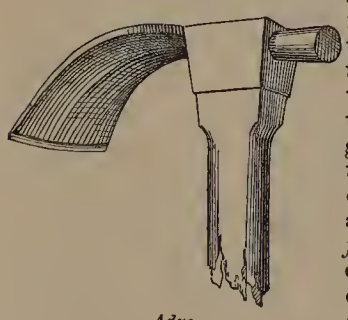
Fig. 35.



with the character of the work, and in some cases the bit is gouge-shaped in addition to its curve in the plane of its motion. It is swung in a path of about the same curvature as the blade, the shoulder-joint being the center of motion, and the entire arm and tool forming, as it were, an inflexible radius.

The above cut from Holtzapffel gives an idea of the presentation to their work of various wood-cutting tools. *a a* represent the axe or hatchet, with two bevels; *b*, the broad-axe, or single-bevelled axe; *c*, the adze; *d*, the Indian angular-bitted adze; *e*, the chisel; *f*, the mode of presentation of a metal-cutting tool, introduced for the sake of comparison.

Fig. 36.

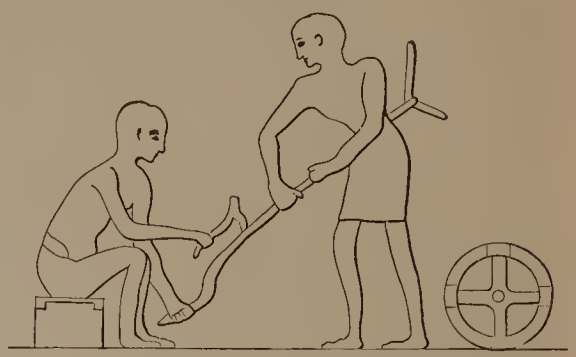


Adze.

Fig. 36 is the modern adze.

The adzes of ancient Egypt were of different forms; the edges curved or straight, the blade generally straight.

Fig. 37.



Egyptian Adze. (Thebes.)

The figures in the accompanying cut are from a building in Thebes; one is holding a carriage-pole or tongue, while the other is dressing it to shape with an adze.

In the other illustration the blade of the adze is shown confined by a band or strap to the helve. The

Fig. 38.

Egyptian Adze. (Thebes.)

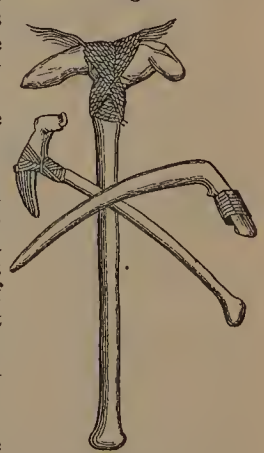
adze appears often in the Egyptian painting and sculpture, and was the principal tool in ancient Egypt for fashioning articles of wood. Its blade was of bronze and the handle of tamarisk.

The Roman adze (*ascia*) is shown on many ancient monuments. Some have a rounded edge, some a straight. It was then, as now, a ship-builder's tool.

The *acisculus* had a similar rounded head, but was a stone-mason's tool, having a square face and pointed peen.

Among many of the West India Islanders adzes and axes of shell were used. When it was procurable they were made of flint; this was worked into the shape of a tool and attached by sinews or cords to a helve, or fastened to a withe (see Axe), or, as in Figs. 39, 40, the cutting material of shell, flint, or obsidian was lashed to a stock. Metal superseded the other materials in most parts of the world, but many barbarous nations of America and Polynesia yet make their weapons of the material generally discarded at a very distant date in the Old World.

Fig. 39.



South-Pacific Adzes.

Fig. 39 represents three stone adzes of the South

Fig. 40.

Chalam Adze.

Pacific, and Fig. 40 a stone adze of the Chalam Indians, who occupy the shores of Puget Sound. It suggests the most ancient form of the tool, employed especially for digging out the canoes from the solid log. These canoes were common at a period before the discovery of iron in Europe, and their remains are there found associated with the implements of the stone and bronze ages.

The stone adze of the Tahitians, when visited by Captain Cook, was similar to those represented in Fig. 39. Large ones for cutting down trees weighed from six to seven pounds; smaller ones, for carving, but a few ounces. All of them needed continual sharpening, for which purpose a stone was kept in readiness.

Adzes are known as

Flat, when the blade has a straight edge;

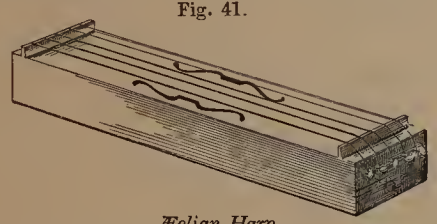
Rounding, when the edge is curved;

Notching, with a straight blade and straight edge.

Æ-o'li-an. A contrivance attached to pianos by which a wind instrument may be introduced as an accessory at the pleasure of the performer, air being supplied by a bellows worked by a pedal.

Æ-o'li-an Harp. A species of musical instrument, the sounds of which are produced by currents of air passing over its strings, which are commonly fifteen in number. Its principle may be familiarly

Fig. 41.



Æolian Harp.

shown on a large scale by the action of the telegraph wires stretched from one pole to another. On a windy day especially these will be found, by any one stationed near, to emit musical tones rising and falling in proportion to the strength of the wind, and more or less grave in proportion to the tension of the wires.

Were the number of wires increased, and their length and tension properly varied, these would constitute a perfect Æolian.

A common mode of construction is to make a box of thin wood and of suitable length, to set beneath a window-sash. It may be five or six inches in width and depth. At one end of the box are pins equal in number to the strings employed, and at the other as many pegs; the strings, being made fast to the pins at one end, are tuned by turning the pegs at the other. The box is open on the sides presented towards the room and to the exterior air, and the strings are sounded by the passage of the air through the box. Catgut is usually employed for the strings.

It is supposed to have been invented by John J. Schnell, musical-instrument maker to the Countess d'Artois. It was suggested by the vibration of the strings of a harp placed in a breezy situation. Exposed for sale in 1789 under the name of *Anemo Chorde*.

Its use was revived by Kircher.

One of the Talmuds says that the harp of David sounded when the north-wind blew on it, and it has been suggested that he had an Æolian, as we understand it. The sounding of his harp by a gust of wind would be nothing extraordinary if it stood near his north window, which was probably open for air and chosen for its coolness and shade in the climate of Judæa. David wrote a good deal in praise of shade and cool drink.

Æ-o-li'na. (*Music.*) A modification of the accordeon, by Wheatstone, leading to the concertina.

Æ-ol'i-pile. Was invented or first described by Hero, of Alexandria. It was a rotary engine, in which steam issued from the ends of bent arms and by reaction rotated the hollow shaft or sphere to which the arms were attached. Hero's engine revolved in the Serapion about 150 B. C., and many applications for patents in the United States and other countries have been made for the same device within a few years past. Inventors seem loth to give up this simplest form of engine, but it is not probable that it will ever prove a useful or economical one.

Fig. 42.

Hero's Steam-Engine.

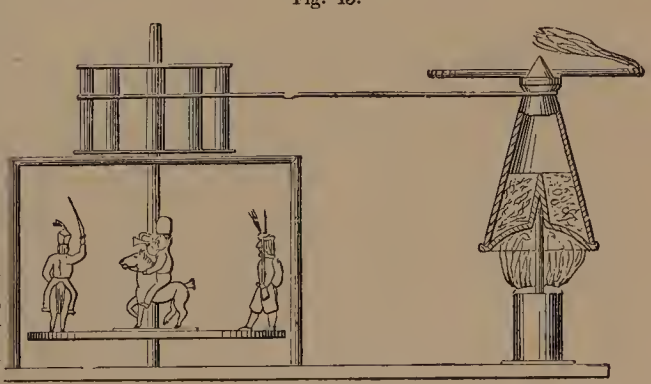
The above cut is copied from Hero's "Spiritalia," edited by Woodcroft, of London. See STEAM-ENGINE.

ELY'S Æolipile, 1867, is adapted for rotating a toy. It is poised with its boiler on a central vertical pivot, and is connected by a band with the shaft on whose platform the toys are displayed.

A more serious attempt at applying the principle of the Æolipile is BANTA'S Rotary Steam-Engine, May 28, 1867. The hollow arms rotate in closed cylinders, and their shafts are so connected as to be continuous, the packing of the series being performed at one operation. The steam passes in at the axis of each, and issues at a tangent, driving the wheel by reaction.

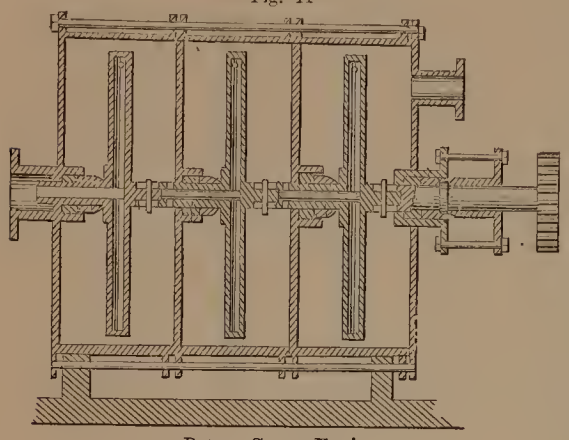
It is attempted to obtain the use of the steam in a number of successive chambers, in apparent forgetfulness of the loss by back-pressure. The steam enters at the left, and, issuing from one pair of arms, escapes into the first chamber; from thence it passes to the second *wheel*, so called, and emerges into the second chamber, and so on. The hubs of the *wheels* are clutched together, so that their cumu-

Fig. 43.



Ely's Æolipile.

Fig. 44



Rotary Steam-Engine.

lative effect is eventually utilized upon the main shaft, on which is the pinion. See REACTION STEAM-ENGINE.

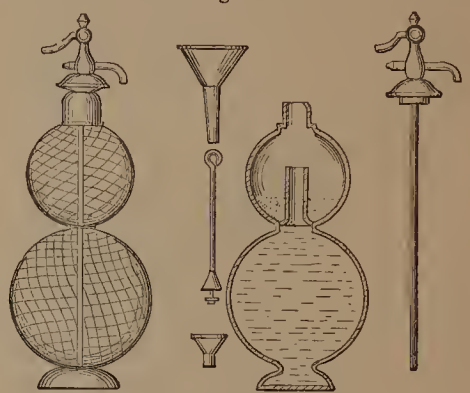
Æ-ol'o-phon. The seraphine; the predecessor of the melodeon and parlor organ.

Æ'o-lus. A small ventilating machine for renewing the air of apartments.

A'er-a'tor. 1. An apparatus for making aërated waters. These consist simply of pure water impregnated either naturally or artificially with gases, and are used largely, when combined with vegetable acids and sugar, as refreshing refrigerating beverages in warm weather, and in medical practice during feverish conditions. The insipid taste of melted snow or rain-water is chiefly due to the small quantities of gases therein contained; but when such water has come in contact with the atmosphere by trickling down a ledge of rocks, and rushing along a boiling, rapid stream, or being dashed to and fro by the winds, it absorbs the gases from the air and is naturally aërated. Ebullition dissipates the gases contained in spring-water, rendering it as flat and insipid to the taste as before it was aërated. The waters of many mineral-springs are aërated in a natural way by the gases arising from the decomposition of minerals washed together from their subterranean beds. The first attempt to prepare artificial aërated waters was made by M. Venel by dissolving in a pint of water two drachms of fossil alkali to which he added an equal quantity of muriatic acid. He used a vessel with a narrow neck to prevent the escape of gas, depositing the ingredients in such a manner that they would not communicate with each other until after the vessel was corked. In this case the gas evolved in a vial nearly full and closely corked suffers such a degree of compression as to greatly promote its combination with the water. M. Venel supposed that the real ingredient to which it owed these qualities was common air. Two memoirs of his experiments were read before the Royal Academy of Sciences in 1750. Dr. Priestley greatly improved upon the discoveries made by Venel and others, and in 1767 contrived an easy method of impregnating water with the principle then denominated "fixed air," by placing shallow pans of water near the surface of the fermenting vessels of a brewery, which in a few hours became pleasantly impregnated with the escaping gas. He found upon experiment that the impregnation was accelerated by pouring the water from one vessel into another; but it did not occur to him till the year 1772 that this could be effected by the gases dislodged from decomposing chalk and other calcareous substances confined in an air-tight vessel. Dr. John North's apparatus for impregnating water with carbonic acid was invented in 1775. Between the years 1807 and 1852 thirty-one English patents were granted for apparatus and methods for preparing aërated water, and fifteen patents for vessels to hold such waters, and for methods for bottling. The most common beverage is *Carbonic Acid Water*, generally spoken of as soda-water, though it seldom contains any soda. It is prepared in large quantities by placing whiting, chalk, or marble-dust in an air-tight, lead-lined vessel with water and sulphuric acid. The sulphuric acid combines with the lime to form sulphate of lime (plaster of Paris), and carbonic acid is evolved as gas. The latter is received in a reservoir, and is afterwards forced into water agitated by machinery so that the latter absorbs about five times its own volume of the gas. The water then constitutes a brisk sparkling liquid, with a pungent but pleasant acidulous taste. It may be prepared on a small scale, for family and medical purposes, by using the apparatus known as the Gazogene or Seltzogene.

The complete apparatus is shown in Fig. 45, and also the separated parts. The lower globe is filled with water by means of the long funnel, and then the tube is closed by the stopper, and the powders, consisting of bicarbonate of soda and tartaric acid, are then placed in the upper globe by means of the small funnel. The stopper is then withdrawn, and the long tube is inserted and screwed closely

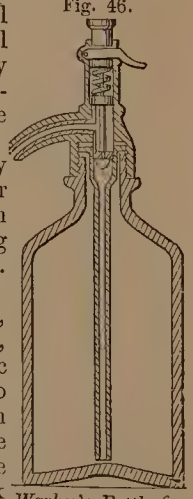
Fig. 45.



Portable Soda-Water Apparatus.

down. The apparatus is then inclined so that the upper globe is about one third filled with water, then placed erect and allowed to stand two hours. If the screw stopcock at the top be opened, the carbonated water will flow out readily into any vessel placed to receive it. Occasionally bisulphate of potash is used instead of tartaric acid, to save the expense of the latter.

Fig. 46.

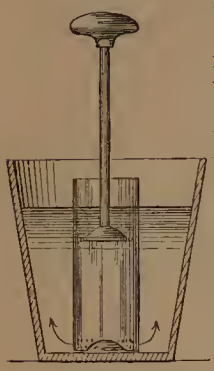


Warker's Bottle for Aërated Liquids.

The devices which are ordinarily called *Soda-Water Apparatus*, or *Soda-Fountains*, are those used in drawing the beverage and mingling it with the flavoring syrups, etc. See SODA-FOUNTAIN.

In the bottle for aërated liquids, patented by WARKER, March 18, 1862, the spout of the metallic fountain-head is lined with glass to keep the liquid from contact with the metal. The shoulder on the top edge of the neck, the alternate grooves, and the ridges on the neck are used to strengthen the attach-

Fig. 47.



Pratt's Aërator.

ment of the metallic cap to which the fountain-head is screwed.

In PRATT'S apparatus for aërating liquids, September 10, 1867, the plunger has a concavity which carries down the air ; the latter is expelled as the plunger reaches the convex bottom, and is driven through the holes in the tube and disseminated through the liquid in the outer vessel.

MEGLONE, August 14, 1866. The tube is introduced through the cork ; the liquid enters holes at its lower end, and is discharged at the goose-neck, when the stop-cock is opened. The bottle may be charged by means of an auxiliary tube, also passing through the cork, and either removed or closed when the bottle is filled with the aërated liquid.

Fig. 48.

Meglone's Soda-Water Bottle.

The liquid contents of these bottles may be aërated by means of a simple air-pump placed in temporary connection with the tube when the eduction nozzle is removed ; or chemicals may be introduced whose reaction liberates gas when they meet in solution. The aëration of sparkling champagne and Catawba is produced by adding a small amount of white sugar to the wine in bottling, the slight fermentation eliminating alcohol therefrom and liberating carbonic acid gas. The effervescing drinks, such as ginger-beer, are also dependent for their ebullition upon the fermentation of the ingredients and the development of the same gas. Carbonic acid, in moderate quantities, has a very salutary effect upon the stomach, while it is so fatal when breathed into the lungs. As the "after damp" or "choke damp" of the miner, it has often killed those who survived the explosion of the carbureted hydrogen. At the Black Hole, near Calcutta, it killed one hundred and twenty-four persons who were confined in a room eighteen feet square by order of Dowlah, Viceroy of Bengal, June 20, 1756. As a gaseous result of the combustion of carbon, — as of charcoal, for instance, — it has destroyed the lives of many who have gone to sleep in ill-ventilated rooms.

Machines are made on a large scale for charging soda-fountains.

CAMERON'S aërator has a gas-generator *a* made of cast-iron, lined with sheet-lead to prevent the action of the sulphuric acid upon the iron. The vessel contains fifteen gallons, and is partially filled with water and whiting or other carbonate of lime. The agitator *b* is also covered with sheet-lead, and its stem passes through a stuffing-box *c*, at the top of the vessel. The acid-holder *e* is formed of lead, and has a capacity of two gallons, and is partially filled with oil of vitriol. The acid is kept from running down into the generator by means of the conical plug *f*, which fits into a conical seat in the leaden pipe *g*. This plug is attached to a rod, and moves up and down through the stuffing-box *h*, and is prevented from turning round by means of a pin *k*, moving in a slit in the bridle *l* ; the screw-nut is riveted loosely into the top of the bridle. The pipe *n*, which forms a communication between the top of the acid-holder *e* and the pipe *s* in which the plug-rod moves, preserves an equilibrium of pressure, so as to prevent the acid from rising higher in the pipe *s* than the level of the acid in the acid-holder ; by which means the brass-work of the stuffing-box is preserved from injury. To prevent any of the sulphuric acid from being carried over by the effervescence, an intermediate vessel *o*, containing about three gallons, is formed of lead or lined with that metal. The intermediate vessel is filled with water above the eduction-pipe from the generator *a*.

The impregnator *v* holds about sixteen gallons, and is made of cast-iron lined with lead, or of tin-lined copper, and the agitator *m* is covered with lead or is made of wood. The impregnator is filled to the dotted line with water, to which, in making saline waters, the proper proportion of sesquicarbonate of soda, carbonate of magnesia, or other ingredients is added.

For the ordinary soda-water no medicament is added. A pressure-gauge *t* is connected by a leaden pipe.

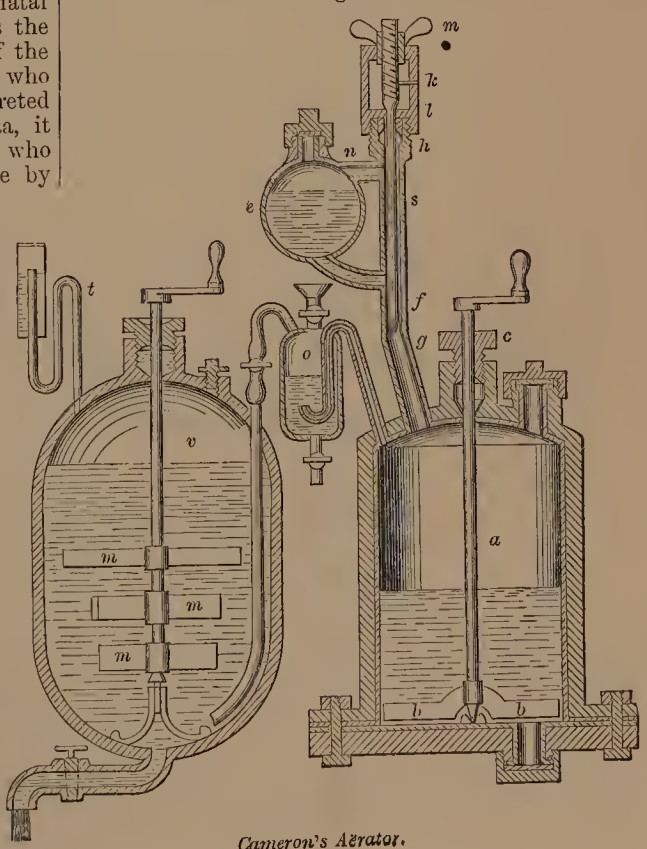
The operation is as follows : —

By turning the nut *m* the plug is raised, and acid is allowed to run into the generator *a*, when it acts upon the carbonate, disengaging the carbonic acid gas in quantity proportioned to the amount of acid admitted. The plug is again lowered when the ascertained proper amount has entered the generator. The gas passes by the intermediate vessel into the impregnator *v*, where it is absorbed by the water.

The aërated water is drawn off from the impregnator into glass bottles, and tightly corked ; or is removed and placed in connection with the ordinary soda-fountain apparatus by which the liquid is drawn into glasses.

BAKEWELL'S soda-water apparatus (English) has the generator and impregnator in the same vessel, separated by a diaphragm, and connected by a pipe.

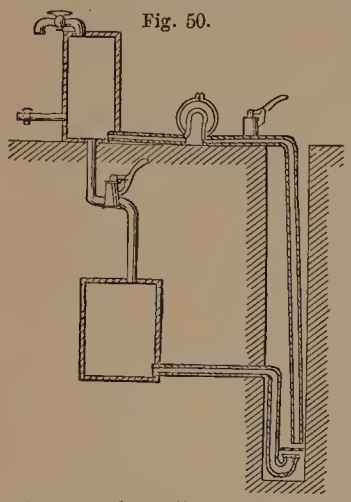
Fig. 49.



Cameron's Aërator.

The vessel is on trunnions, and is oscillated so as to allow a pendulous stirrer in the lower vessel to agitate the solution of the carbonate of lime. The gas passes to the upper chamber, where it performs a circuitous course in the water which absorbs it.

Fig. 50.



Apparatus for bottling at the Spring.

Other apparatus depends upon mechanical means for injecting the gas into the water by means of a pump or syringe.

Many other devices might be cited, but they contain substantially the same parts under modified arrangements, — a generator with a means for admitting the acid, a conductor for the gas, and an impregnator in which the water is permeated by the gas evolved.

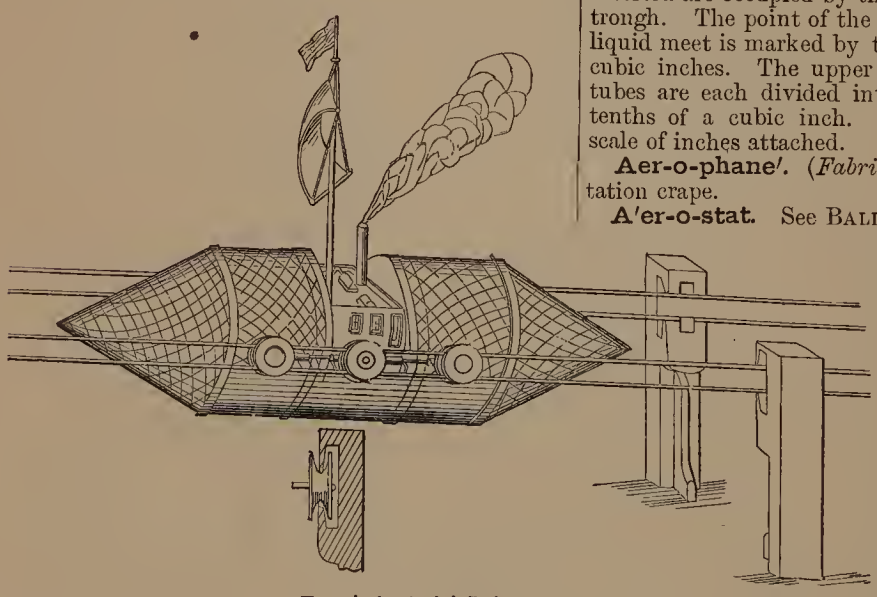
THOMAS'S apparatus for bottling mineral waters, June 18, 1867, is applied directly at the spring.

The water is drawn from a considerable depth through a pipe let down in the spring; a perforated plate of glass is placed in the water below the mouth of the tube, and jets of gas from a reservoir are discharged below the plate.

The object is to charge mineral-water with gas, or to add an extra supply of gas thereto.

2. A contrivance for fumigating grain in bulk, to destroy fungi and insects.

Fig. 51.



Fontaine's Aërial Railway.

A-e'ri-al Car. A car adapted for traveling in the air.

The name is somewhat loosely applied, and may mean one of three things: —

1. The basket or receptacle of a balloon.

2. A car whose weight is partially or entirely counterbalanced by a balloon, and which travels on wires by means of driven wheels. See next article.

3. A car on an elevated railway.

A-e'ri-al Rail'way. An attempt to govern the balloon or aërostat by guiding rails or wires stretched between posts.

FONTAINE'S Aërial Railway, February 5, 1867, may be taken as a sample.

The weight of the car is counterbalanced by an attached balloon. The cigar-shaped car is driven by steam, the deeply indented side-wheels travelling upon wires which rest upon brackets whose flanges project into the circumferential depressions in the wheels.

The wire-way supported on posts has been adopted for carrying freight. See WIRE-WAY.

A'e-ro-hy'dro-dy-nam'ic Wheel. A mode of transmitting power to great distances proposed by a Belgian engineer, Mr. Calles. The plan of Mr. Calles is to make use of air under a certain degree of compression as the vehicle of the force to be transmitted, not by accumulating the air thus employed in reservoirs, but by driving it, by the operation of the original motor, directly into a tube extending to the point of final application, where it is to be discharged beneath a wheel submerged in water, which it is to turn by its ascensional force. See AIR AS A MEANS OF TRANSMITTING POWER.

A'er-om'e-ter. An instrument invented by Dr. M. Hall, for ascertaining the mean bulk of air or gases in pneumatic experiments.

It consists of a bulb of glass of four and one half cubic inches' capacity, blown at the end of a long tube whose capacity is one cubic inch. This tube is inserted into another tube of nearly equal length, which is supported on a sole, and the first tube is sustained at any required height within the second by the pressure of a spring. Five cubic inches of atmospheric air, at a medium density and temperature, are introduced into the bulb and tube, of the latter of which it will occupy one half. The other half of this tube and part of the tube in which it is inserted are occupied by the liquid of the pneumatic trough. The point of the tube at which the air and liquid meet is marked by the figure 5 to denote five cubic inches. The upper and lower halves of the tubes are each divided into five parts, representing tenths of a cubic inch. The external tube has a scale of inches attached.

Aer-o-phane'. (*Fabric.*) A light gauze or imitation crape.

A'er-o-stat. See BALLOON.

A'e-ro-steam En'gine. An engine in which the expansive power of combined heated air and steam is used in driving a piston.

The *Air Engine* followed closely in the wake of the Watt Steam-Engine.

Oliver Evans, during the latter portion of the last century, suggested the combination of the heated gases and air with the steam, as a motor. He called it a VOLCANIC ENGINE, which see.

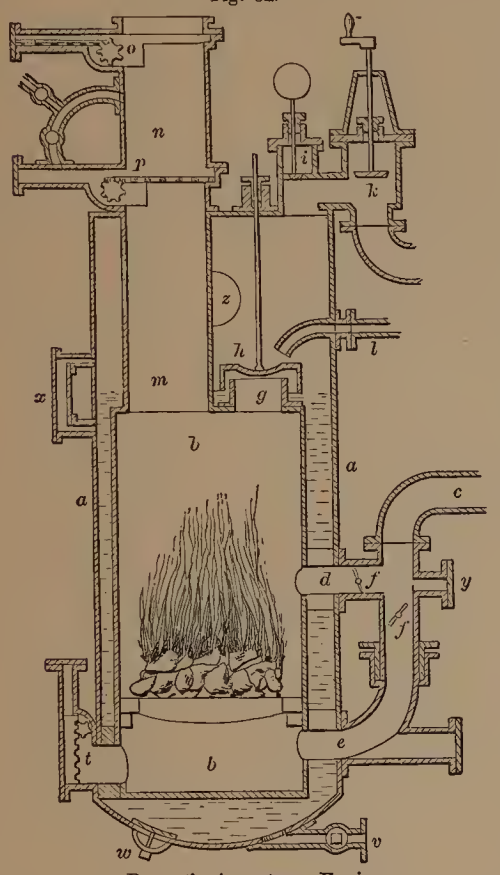
Glazebrook used moistened hot-air in his Air Engine, English Patent, 1797. See AIR ENGINE.

The air is moistened before reaching the cylinder in PAINE'S Engine, United States Patent, November 30, 1858. In this case it is the cool refrigerated air that is moistened, and the amount of moisture

would be very far below saturation when the air came to be heated.

The same may be said of Glazebrook's, 1797, with the additional remark that Glazebrook condensed the air in the preliminary process, before exposing it to moisture, so that the heat incident to its condensation would enable it to absorb more water, but still far less than would be sufficient to saturate it when it came to be heated by the furnace.

Fig. 52.



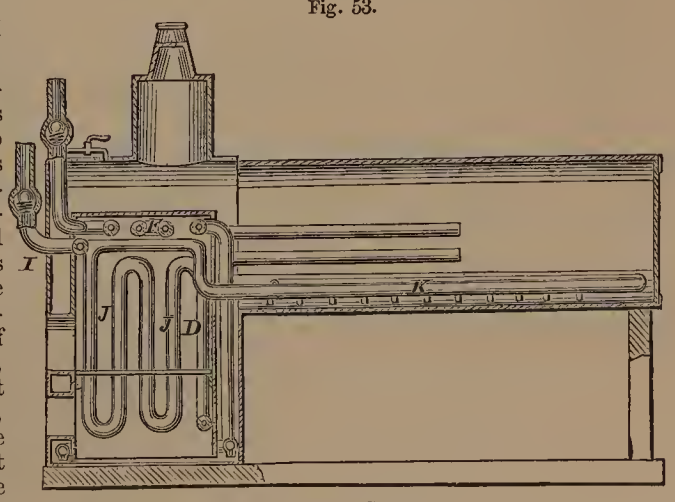
Bennett's Aëro-steam Engine.

Bennett, United States Patent, August 3, 1838, introduced, or at least adopted, two new features: 1. He conducts the incoming charge of air to the furnace, and makes it the means of maintaining combustion under pressure; 2. The furnace is air-tight, and the volatile results pass through the steam-boiler, are washed, and pass, fully saturated, to the cylinder. See Air Engine.

The steam and air might have been combined in any required relative ratio in this boiler, but the inventor does not appear to have supposed any specific proportion was necessary. *a a* is a vertical cylinder constituting the shell of the boiler, *b b* a smaller cylinder placed within the former and forming the furnace and ash-pit; this is entirely surrounded by water. *c* is a tube connected with a blowing-machine, and having two branches *d* and *e*, — the former of which admits a portion of air above the fuel, and the latter a portion into the ash-pit below the fire-bars. Two throttle-valves, or dampers, *f f*, are provided to regulate the draft through each branch. *g* is a short cylindrical neck, through which the smoke and heated air pass into the steam-chamber, where they mix with the steam, and with it pass to the working cylinders. The neck *g* is covered with a valve *h* opening upward, the sides of which are turned down to cause the heated air to pass through the water, and thereby give out a portion of its heat to the latter; this also serves to wash the heated air and arrest grit which would injure the cylinder and piston. *i*, a safety-valve, *k*, a valve by which the pipe that conveys the steam to the engine can be closed when required; *l*, the pipe by which the water is conveyed to the boiler from the feed-pump; the end of this pipe enters the boiler and delivers the water on to the top of the valve *h*; this is with a view to prevent the valve becoming excessively heated by the action of the fire. *m* is the fuel-spout by which coal is introduced into the fireplace; on it is bolted the hopper *n*, having at its upper end a flat sliding valve *o*, and another one *p* at its lower end; these valves slide in grooves, and are moved by means of racks and pinions. They are ground to their seats so as to make air-tight joints, and during the whole time the engine is in operation the coal-hopper is kept closed by one or other of these valves. In kindling the fire the valves *o* and *p* are both opened, lighted kindling is dropped through the chute, and then a quantity of fuel. The valves are then closed, the blower started. When the engine is set to work, it forces air into the furnace both above and below the fuel at each stroke, which, having no vent to escape but at the valve *h*, accumulates in the furnace until its pressure somewhat exceeds that of the steam upon the valve *h*, when it lifts the valve, and, rising up through the water, mixes with the steam, and passes along with it to the engines. *t* is a slider, by opening which the ashes from the furnace can be withdrawn; when this is requisite the dampers *f f* must be first closed. *v* is the blow-off cock, by which the water can be discharged from the boiler when required, and *w* is a hole covered by a door for removing any mud which may have accumulated. At *x* is a glass gage to show the height of the water in the boiler, and at *y* is a glass eye-piece through which the state of the fire can be ascertained. *z* is the man-hole of the boiler.

William Mont. Storm's experiments in combined air and steam covered the period 1851–55, and perhaps later. His Cloud Engine, in which steam and air, in a condition resembling fog, were used to propel a piston, was exhibited at the fair of the American Institute, New York, in 1855. The machine appears to have failed to realize the expecta-

Fig. 53.



Tanger's Steam-Generator.

tions of the inventor. There was a lack of adjustment somewhere, it may be supposed, but the end is not yet.

In WASHBURN's Air-Heater and Steam-Generator, United States Patent, September 5, 1865, the air is also introduced under pressure into the furnace, and then passed through a cleansing-tank before being added to the steam evolved in the coil of pipe which constitutes the steam-generator. In this apparatus full saturation is obtained. See illustration in AIR ENGINE.

STILLMAN's Hot Air and Steam Generator, August 9, 1864, has also the combination of air and steam.

BICKFORD's Patent, June 6, 1865, may also be examined in this connection.

In TANGER's Steam Generator, December 4, 1866, the air is injected into the pipes *E* and *I* by means of a force-pump, and after being heated while passing through the convolutions of the pipes *F* and *J*, is forced into the boiler by nipples, as shown at *K*.

In TARR's Aëro-Steam Engine, 1867, the air is heated within the furnace, and is thence forced through the pipe into the steam-chest, where it mingles with the steam coming through the pipe; and the mixture of steam and hot air is by means of a slide-valve admitted alternately above and below the piston in the ordinary way, so as to produce the usual reciprocating motion.

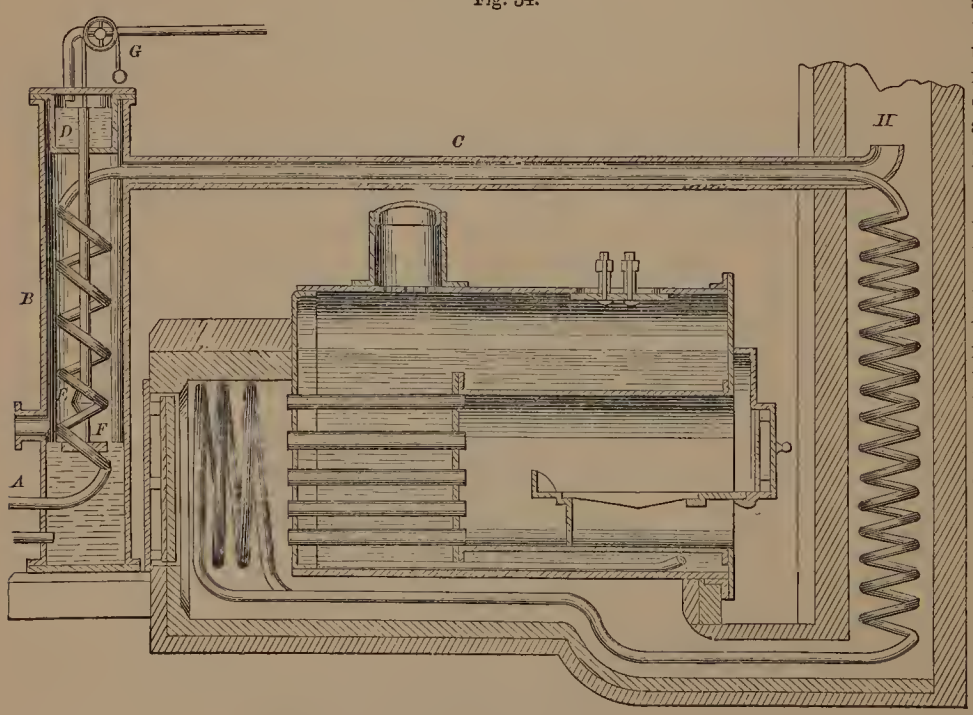
WARSOP's Engine (English), 1869, is started by steam in the ordinary manner. A single-acting air-pump, worked from the crank shaft, compresses air to a little more than the boiler pressure; the air then passes through a long circuit of straight and coiled pipe, which traverses the exhaust-pipe, makes several spiral coils in the chimney, then descends at one side of the fire-box, is exposed to the full fire, and finally passes by a valved opening into the boiler at the bottom of the water-space.

Warsop's object is similar to that of several of his predecessors, to make steam assist the expansive force of air, and to avoid the difficulties of lubrication incident to the use of hot air alone. He attempts to obtain the maximum effect from mixed air and steam by instituting a certain approved proportion between the two. It is quite probable that such a ratio may be found, and that it may secure substantial economical advantages.

The pipe *A*, through which the air is forced into the boiler by the action of the air-pump, is of iron, and is $1\frac{1}{16}$ inches in diameter outside, and $1\frac{1}{4}$ inch bore. On leaving the pump the pipe is first led to the heater *B*, shown on the left of the engraving, wherein it is exposed to the exhaust steam. The heater consists, as will be seen, of a cast-iron cylindrical vessel placed in a vertical position and provided with two branches — one near the bottom and the other near the top — through which the exhaust steam respectively enters and escapes from the casing. At the top of the heater is placed a small cylindrical tank *D*, exposed at the bottom and sides to the exhaust steam, and perforated around the upper part of the sides, so that in the event of its receiving an excess of water the latter may overflow and fall to the bottom of the heater. Through a stuffing-box at the bottom of the tank there passes a tube with a rose *E* at the lower end, this tube being carried by a float *F*, which swims in the water at the bottom of the heater, as shown, and, by means of a cord passing from the top of the tube, works a cock *G*, which regulates the supply of water to the tank at the top of the heater.

The air-pipe *A*, after leaving the heater just described, passes along the exhaust-pipe *C* to the chimney *H*, and, descending the latter spirally, as shown, passes into the flue beneath the boiler. Here it is led backward and forward, as shown in the plan, and after making several convolutions in the smoke-box, is led back to the front of the boiler, where it communicates with a valve-box, containing an ordinary, light clack-valve. The object of this valve is to prevent water from entering the air-pipe when the engine is stopped. From the valve-box a pipe is led down within the boiler to the bottom of the latter, this pipe being perforated at intervals on the upper side. The perforations are placed closer together at the farther end of the pipe than they are at the end at which the air enters, and by this means an equable distribution of the air at the different parts of the boiler is insured.

Fig. 54.



Warsop's Aëro-Steam Engine Boiler.

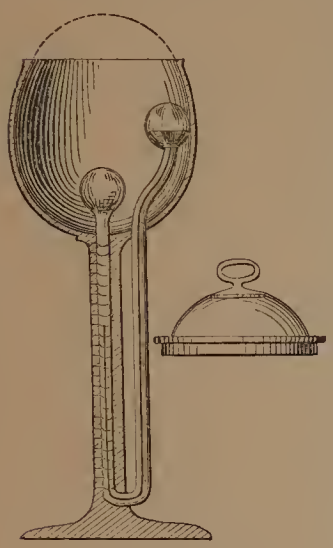
The lengths of the various portions of the air-pipe are as follows: In feed-water heater, 12 feet; in exhaust-pipe, 13 feet 6 inches; in chimney and flues, including coils in smoke-box and under boiler, 58 feet; total, 83 feet 6 inches. The total external surface exposed by this pipe is thus about $36\frac{3}{4}$ square feet.

The principal dimensions of the

boiler are as follows: Length, 8 feet; diameter of shell, 3 feet 6 inches; diameter of fire-box flue, 2 feet 2 inches; length of fire-box and combustion-chamber, 5 feet; and length of tubes, 3 feet. The tubes are 41 in number, most of them being $2\frac{5}{8}$ inches, and some of them $2\frac{5}{16}$ inches diameter. The total effective heating surface exposed by the boiler is about 130 square feet.

Æ'thi-ops Min'er-al. A compound of sulphur and mercury, so called on account of its blackness. The black sulphuret of mercury, formed by triturating together mercury and sulphur until the two combine and form a black powder.

Fig. 56.



Æthrioscope.

Æ'thri-o-scope. An instrument for measuring the degrees of cold arising from exposure under different conditions of the sky. A highly polished metallic cup or concave mirror is placed upon a pedestal of convenient hight, and a differential thermometer is placed within it so that one of the bulbs of the thermometer shall be exactly in one focus of the mirror; the other bulb being not in either focus is not affected by the pulsations, the effects of which on the cup are concentrated upon the first bulb, the air in which being suddenly contracted upon its exposure to a clear sky, the liquid in that branch of the stem is caused to rise. The cup is kept covered with a metallic plate, except at the moments of observation.

Af'fi-nage. The act of refining or making purer, as the affinage of metals.

Aft'er-rake. The part of the stern which overhangs the keel.

Aft'er-sail. (*Nautical.*) A sail whose center of effort is abaft the general center of effort of all the sails. Head-sails are relatively before the said point, and by means of these head and after sails a ship may be maneuvred.

Aft'er-tim'bers. (*Shipbuilding.*) 1. Radiating cant-frames, abaft the fashion-pieces and below the wing-transom, stepped partly on the dead-wood and partly on stepping-pieces bolted to the sides of the inner stern-post.

2. Those abaft the midship section.

Ag'a-ba'nee. (*Fabric.*) Cotton embroidered with silk, made in Aleppo.

Ag'ate. (*Printing.*) 1. A size of type between Pearl and Nonpareil; called Ruby in England.

Pearl.
Agate, or Ruby.
Nonpareil.

2. The draw-plate of the gold-wire drawers; so called because the drilled eye is an agate.

3. The pivotal cup of the compass-card.

Age'ing. (*Pottery.*) The storage of prepared clay, to allow it time to ferment and ripen before using. The *slip*, consisting of levigated clay and flint, is run in a thin solution through sieves and brought to a creamy consistence. This is boiled down to give it more solidity, and is then stored away, sometimes for years, being occasionally cut out in chunks and slapped to expel air and develop the plasticity. During the *ageing* process a slight fermentation occurs, carbonic acid and sulphureted hydrogen are disengaged, and the mass is improved in texture and quality. The clay is thus allowed to temper in cellars or under cover, sometimes for several years.

In China, a potter prepares the clay for the succeeding generation while working up that bequeathed to him by his ancestors.

(*Wine and Liquors.*) Devices for this purpose subject the liquid to heat and agitation; some of them using the combined action of heat, electricity, and attrition. See WINE-AGEING APPARATUS.

(*Calico Printing.*) The exposure of printed calicoes in a sufficiently moist and warm air to allow the colors to permeate and mature. An apparatus was patented by Thom, England, for applying air loaded with moisture of a given temperature to the printed fabric, which is then folded and allowed to rest for a few hours in that condition.

A-gist'ment. A dike or embankment to prevent the overflow of land abutting upon a stream or the sea.

Ag'i-ta'tor. A rotating beater or armed shaft for mixing and disturbing articles mechanically suspended in water, such as

The *pulp* in the stuff-chest of a paper-machine.

The *mash* in the mash-tub of a brewery.

The mixture of starch, sugar, etc., and water, in the washing process of starch-making.

Ag'ri-cult'ur-al Im'ple-ments. These are treated, as fully as the limits will permit, under their respective heads; it is needless to repeat here the history of their progressive development or the order of their succession. See the following, under their respective heads: —

AGRICULTURAL AND HUSBANDRY IMPLEMENTS, ETC.

Aberuncator.
Animal-clutch.
Animal-poke.
Apiary.
Atmospheric churn.
Auger. Earth-boring.
Aveler.
Averuncator.
Awner.
Bagasse-dryer.
Bag-fastener.
Bag-holder.
Bag-tie.
Bale-tie.
Baling-press.
Band for baling.
Band for binding grain.
Band-cutting machine.
Barking-tools.
Barley-chumper.
Barley-fork.
Barley-huller.
Bar-share plow.
Basket.
Bean-harvester.
Bean-mill.
Bee-feeder.
Bee-fumigator.
Beehive.
Beehive, swarm-indicator for
Bee-tax.
Belly-roll.
Bill.
Bill-hook.
Binder.
Binding attachment for harvesters.
Binot.
Blade.
Bob-sled.
Bog-cutting plow.
Bott-hammer.
Bow. Ox
Braking-machine.
Branding-tool.
Breast-plow.
Brier-scythe.
Broach.
Broadcast-sower.
Bruising-machine.
Brush-puller.
Buggy-cultivator.
Bull-nose ring.
Bush-harrow.
Bush-scythe.
Butter-mold.
Butter-tongs.
Butter-worker.
Calorifier.
Cane-harvester.
Cane-scraper.
Cane-stripper.
Cattle-feeder.
Cattle-leader.
Cattle-pump.
Cattle-stall.
Cattle-tie.
Caving-rake.
Chaff-cutter.
Cheese-cutter.
Cheese-hoop.

Cheese-knife.
Cheese-shelf.
Cheese-vat.
Chessel.
Chicken-raising apparatus.
Chopness.
Chopper.
Churn.
Churn-dasher.
Churn-power.
Cider-mill.
Cider-press.
Clevis.
Clod-crusher.
Clover-harvester.
Clover-huller.
Clover-thrasher.
Clutch for catching animals.
Cockle-separator.
Colter.
Corn-coverer.
Corn-crib.
Corn-cultivator.
Corn-cutter.
Corn-harp.
Corn-harvester.
Corn-huller.
Corn-husker.
Corn-husk splitter.
Corn-knife.
Corn-planter.
Corn-plow.
Corn-row marker.
Corn-sheller.
Corn-shocking machine.
Corn-stalk cutter.
Corn-stripping knife.
Cotton-brush chopper.
Cotton-chopper.
Cotton-cultivator.
Cotton-gin.
Cotton-picker.
Cotton-press.
Cotton-scraper.
Cotton-seed cleaner.
Cotton-seed planter.
Cotton-seed preparing.
Cotton-topper.
Cow-milker.
Cradle.
Cranberry-gatherer.
Cream slice.
Croom.
Cultivator.
Cultivator plow.
Curculio-trap.
Curd-breaker.
Curd-cutter.
Cutter. Harvester
Cutting-box.
Diamond plow.
Dibble.
Dibbling-machine.
Digger.
Digging-machine.
Ditching-machine
Ditching-plow.
Ditching-tools.
Double plow.
Double-mold-board plow.
Double shovel plow.
Drag.
Draining-plow.
Drill. Barrow.
Drill. Grain.
Drill. Harrow.
Dropper.
Dumping-reel.
Dung-fork.
Dung-hook.
Edging shears.
Egg-hatching apparatus.
Expanding plow.
Fanning-mill.
Feed-bag.
Feed-cutter.
Feed-rack.
Fence.
Fence-jack.
Fence-post.
Fence-post driver.
Fertilizer-sower.
Fiddle.
Finger.
Flail.
Flax-brake.
Flax-puller.
Flax-scutcher.
Flax-thrasher.
Flax-washer.
Fleece-folder.
Flower-pot.
Fork.
Fork. Horse hay-
Fruit-dryer.
Fruit-frame.
Fruit-gatherer.
Fruit-ladder.
Fruit-picker.
Fruit-preserving house.
Fruit-press.
Fumigator.
Furrowing-plow.
Gage wheel.
Gallows.
Gang-cultivator.
Gang-plow.
Garden ladder.
Garden shears.
Garden syringe.
Garlic-separator.
Gate.
Gate-post.
Gaveling attachment for harvesters.
Grafting-chisel.
Grain-binder.
Grain-bruiser.
Grain-cleaner.
Grain-conveyer.
Grain-cradle.
Grain-drill.
Grain-dryer.
Grain-fork.
Grain-harvester.
Grain-rake.
Grain-sacker.
Grain-screen.
Grain-separator.
Grain-shovel.
Grain-thrasher.
Grain-wheel.
Graip.
Granary.
Grapery.
Grape-trellis.
Grass-harvester.
Grass-seed separator.
Ground auger.
Grubber.
Grubbing-axe.
Grubbing-hoe.
Guard finger.
Hackling-machine.
Hair-clipping shears.
Hand-cultivator.
Hand-planter.
Harle.
Harrow.
Harvester rake.
Harvesting-machine.
Hasp.
Hay-band machine.
Hay-cutter.
Hay-fork.
Hay-knife.
Hay-loader.
Hay-press.
Hay-rack.
Hay-rake.
Hay-raker and cocker.
Hay-spreader.
Hay-stacker.
Hay-tedder.
Hay-unloader.
Heading-machine.
Hedge-planter.
Hedge-clipper.
Hedge-shears.
Hedging tools.
Hemp-brake.
Hemp-harvester.
Hen's-nest.
Hink.
Hive.
Hoe.
Hoe. Horse.
Hoe-plow.
Hog-elevator.
Hog-hook.
Hog-nose-trimmer.
Hog-ring.
Hog-scalding tub.
Honey-strainer.
Hop-frame.
Hopple.
Hop-pole.
Hop-press.
Horse hay-fork.
Horse-hoe.
Horse-power.
Horse-rake.
Horseshoe.
Hot-bed frame.
Humbug.
Hummeling machine.
Hurdle.
Husker.
Husking-peg.
Incubator.
Insect-exterminator.
Insect trap.
Jumper.
Kibbling-machine.
Lactometer.
Lactoscope.
Ladder.
Land-paring machine.
Lap-ring.
Lard-cutter.
Lard-renderer.
Lawn-mower.
Layering implements.
Leveler.
Lime-spreader.
Manger.
Manure-drag.
Manure-drill. Liquid
Manure-fork.
Manure-hook
Manure-loader.
Manure-spreader.
Marking-plow.
Mattock.
Maul.
Milk-can.
Milk-cooler.
Milking apparatus.
Milk-rack.
Milk-shelf.
Milk-strainer.
Milk-vat.
Mole-plow.
Mollebart.
Moth-trap.
Mower.
Muck-fork.
Muck-rake.
Muzzle.
Nib.
Osier-peeler.
Ox-shoe.
Ox-yoke. (See Yoke.)
Paring-plow.
Peanut-digger.
Pea-rake.
Peat-machine.
Peeling-iron.
Pickaxe.
Picker. Cotton
Picket.
Pitchfork.
Planter.
Plow (varieties; see Plow).
Plow-cleaner.
Poke.
Portable fence.
Post-auger.
Post-driver.
Post-hole borer.
Post-hole digger.
Post-jack.
Post-puller.
Potato-digger.
Potato-hook.
Potato-planter.
Potato-scoop.
Potato-separator.
Poultry-feeder.
Powder-blower.
Prairie-plow.
Propagating-box.
Pruning-shears.
Pruning-tools.
Rack.
Rake.
Raker and loader.
Rake-harvester.
Rake. Horse hay.
Reaper.
Reaping-hook.
Reaping-machine.
Reel. Harvester
Reversible plow.

Rice-cleaner.
Riddle.
Ridging-plow.
Ripple.
Roller. Land
Root-bruiser.
Root-cutter.
Root-digger.
Root-grinder.
Root-washer.
Rotary cultivator.
Rotary digger.
Rotary harrow.
Rotary plow.
Rotary spader.
Rudder.
Sap-bucket.
Sap-bucket hook.
Sap-spile.
Scarifier.
Scoop.
Scraper.
Scuffle-hoe.
Scuffler.
Scythe.
Seed-drill.
Seeding-machine.
Seeding-plow.
Seed-planter.
Seed-sower.
Separator.
Share.
Shears. Pruning
Shears. Sheep.
Sheep-dipping apparatus.
Sheep-foot trimmer.
Sheep-holder.
Sheep-rack.
Sheep-shearing machine.
Sheep-shearing table.
Sheep-shears.
Sheep-washing apparatus.
Sheller. Corn
Shovel.
Shovel plow.
Sickle.
Side-hill plow.
Single-shovel plow.
Skeleton plow.
Skid.
Skim-colter plow.
Skimming apparatus.
Slaughtering apparatus.
Smoke-house.
Smut-machine.
Snath.
Snouter.
Snout-ring.
Snow-shovel.
Sod-cutter.
Sod-plow.
Sorghum-evaporator.
Sorghum-stripper.
Sower.
Spade.
Spading-machine.
Spud.
Stable-cleaner.
Stack-borer.
Stacker.
Stacking derrick.
Stack-stand.
Staddle.
Stalk-cutter.
Stalk-puller.
Stall.
Steam-engine. Agricultural
Steam-plow.
Stock-feeder.
Stocks for refractory animals.
Stone-boat.
Stone-gatherer.
Straddle-plow.
Straw-carrier.
Straw-cutter.
Stubble-turner.
Stump-extractor.
Subsoil plow.
Sugar-cane planter.
Sulky plow.
Sward-cutter.
Swather.
Sweet-potato cultivator.
Swing-moldboard plow.
Swing plow.
Tedder.
Tether.
Thatching.
Thistle-digger.
Thrasher.
Tobacco-curing apparatus.
Tormentor.
Track-clearer.
Transplanter.
Treble-shovel plow.
Tree-digger.
Tree-protector.
Tree-remover.
Tree-scraper.
Trellis.
Trowel.
Turf-cutter.
Turnip-puller.
Turnwrest plow.
Vegetable-chopper.
Vegetable-slicer.
Vegetable-washer.
Weeding-hoe.
Wheel-colter
Wheel-cultivator.
Wheel-plow.
Whitening-machine.
Willow-peeler.
Winnowing-machine.
Wool-packer.
Wool-packing table.
Wool-press.
Yoke.

Ag'ri-cult'ur-al Steam'-en'gine. A steam-engine specifically adapted for use in thrashing and some other farm operations. Its principal peculiarity consists in compactness and portability. See PORTABLE STEAM-ENGINE.

Aich's Met'al. An alloy of copper, zinc, and iron, used for guns. Patented in England, February 3, 1860, by Johann Aich, Imperial Arsenal, Venice. It is composed as follows: —

Copper,	60.
Zinc,	38.125
Iron,	1.5

It resembles the Keir metal, English patent, December 10, 1779, which has, —

Copper,	100	or,	100
Zinc,	75		80
Iron,	10		10

Also the sterro-metal of Rosthorn, Austria, 1861, which has, —

Copper,	55.04	or,	57.63
Tin,	0.83		0.15
Zinc,	42.36		40.22
Iron,	1.77		1.86

Austrian navy brass has, —

Copper,	60.
Zinc,	38.12
Iron,	1.8

Chinese Packfong has, —

Copper,	40.04
Zinc,	25.4
Iron,	2.6
Nickel,	31.6

See ALLOY.

Ai'guille. A needle. Among masons, a stone-boring tool. A priming-wire.

Aim-front'let. A piece of wood hollowed out to fit the muzzle of a gun, so as to make it level with the breech, formerly in use among gunners. Wooden front-sights on a similar principle are still used on board ship in case of emergency, as when an accident occurs to the proper metal sights.

Air and Steam En'gine. See AËRO-STEAM ENGINE.

Air Appliances and Machinery.

Acetifier.
Acoustic instruments.
Acoustic telegraph.
Æolus.
Aërator.
Aërial railway.
Aëro-hydro-dynamic wheel.
Aërostat.
Aëro-steam-engine.
Air and steam engine.
Air as a means of transmitting power.
Air as a water-elevator.
Air-bath.
Air bed and cushion.
Air-blast.
Air-brick.
Air-carbureting.
Air-casing.
Air-chamber for pumps.
Air-compressing machine.
Air-cooling apparatus.
Air-cushion for pipes.
Air-drain.
Air-drill.
Air-engine.
Air-escape.
Air-exhauster.
Air-filter.
Air-fountain.
Air-grating.
Air-gun.
Air-heater.
Air-holder.
Air-jacket.
Air-level.
Air-lock.
Air-machine.
Air-meter.
Airohydrogen blow-pipe.
Airometer.
Air-pipe.
Air-poise.
Air-pressure filter.
Air-pump.
Air-regulator
Air-scuttle.
Air-shaft.
Air-spring.
Air-stove.
Air-thermometer.
Air-trap.
Air-trunk.
Air-tube for conveyance.
Air-valve.
Air-vessel.
Anemograph.
Anemometer.
Anemoscope.
Aspirator.
Atmospheric alarm.
Atmospheric churn.
Atmospheric engine.
Atmospheric governor.
Atmospheric hammer.
Atmospheric railway.
Atmospheric spring.
Atomizer.
Auricle.
Balloon.
Bellows.

Blast.
Blast machine.
Blast-nozzle.
Blower.
Blowing-machine.
Blowing-tube.
Blow-pipe.
Caloric engine.
Captive balloon.
Carbonic-acid engine.
Carbureting-machine.
Car-ventilator.
Cold-blast.
Compressed-air engine.
Cupping-pump.
Cylinder blower.
Detonating tube.
Dispatch-tube.
Diffusion-tube.
Disinfecting apparatus.
Ear. Artificial
Ear cornet.
Ear instruments.
Ear-trumpet.
Eccentric fan-blower.
Ejector.
Eudiometer.
Exhaust fan.
Fan.
Fan-blower.
Fanner.
Fanning-machine.
Fanning-mill.
Fan-ventilator.
Fire-extinguisher.
Flighter.
Flying-machine.
Foot-bellows.
Fumigator.
Graduator.
Gunpowder engine.
Hydrostatic bellows.
Inhaler.
Insect exterminator.
Insufflator.
Leech. Artificial
Life-preserver.
Magdeburg hemispheres.
Mulguf.
Organ.
Parachute.
Pneumatic drill.
Pneumatic lever.
Pneumatic pile.
Pneumatic pump.
Pneumatic railway.
Pneumatic spring.
Pneumatic trough.
Pneumatic tube.
Pneumatic tubular dispatch.
Pneumatic valve.
Pneumatometer.
Punkah.
Respirator.
Rotary blower.
Rotary fan.
Sand-bellows.
Sand-blower.
Screw ventilator.
Sirene.
Smoke-jack.
Sonifer.
Sonometer.
Sound-board.
Speaking-tube.
Speaking-trumpet.
Spirometer.
Stench-trap.
Thermometric ventilator.
Tonometer.
Torricellian vacuum.
Trompe.
Tuyere.
Vacuum apparatus.
Vacuum-filter.
Vacuum-gage.
Vacuum-pan.
Vacuum-pump.
Vane.
Ventilating millstones.
Ventilator.
Water-bellows.
Wind-car.
Wind-chest.
Wind-cutter.
Wind-furnace.
Wind-gage.
Windmill.
Windmill-propeller.
Wind-pump.
Wind-sail.
Wind-trunk.
Wind-wheel.

Air as a Means of transmitting Power. So far as our information extends, the first person to use compressed air as a means of transmitting power was that ingenious Frenchman, Dr. Papin of Blois, about A. D. 1700. We shall have occasion to refer to him in the History of the Steam-Engine. He was the first to apply a piston in the steam-cylinder, and was the inventor of the digester, and the steelyard safety-valve, — the best and simplest effective form yet devised.

Papin used a fall of water to compress air into a cylinder, and led it thence by a pipe a distance of a mile. Having reached its destination, it was employed to drive a piston in a cylinder, the power being intended to work a pump. The distance, the friction, and the leakage were too much for the Doctor, and the inversion of the process, making the primary engine exhaust instead of condensing, had no better effect. Thinking that it was the volume of air in the pipe which made the second cylinder unresponsive to the action of the primary cylinder, he reduced the size of the pipe, but still the pumping-machine would not move. In Auvergne and Westphalia the project was tried on an extensive scale, attempts being made to drain mines by these means.

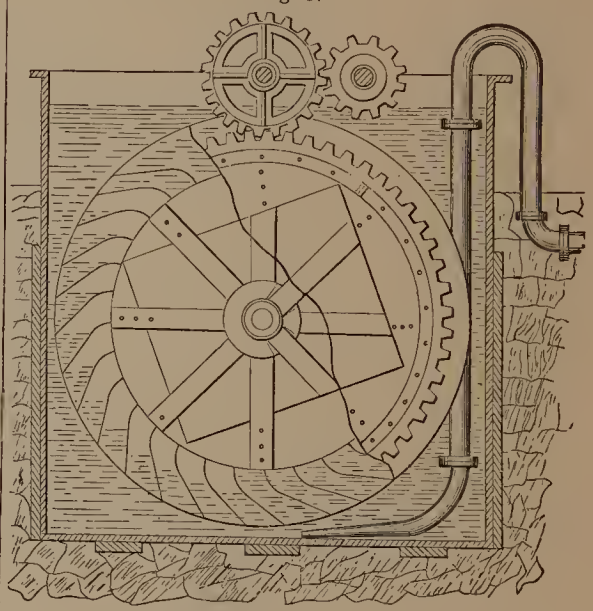
About one hundred years after the experiment of the philosopher of Blois, a Welsh engineer used the power derived from a heavy fall of water to work a blowing-cylinder from which air was conveyed to a blast-furnace a distance of a mile and a half. The resulting blast was feeble.

Some forty years since, a Mr. Hague took out an English patent for the application of compressed air to working-cranes, hoisting-machines, and other machinery. The air was compressed by an air-pump at a central location, and the air conducted by pipes to the cranes and other machinery of a series of docks and warehouses.

The same inventor also applied an air-exhaust to raising a tilt-hammer. See ATMOSPHERIC HAMMER.

The subjoined cut has a remarkably unpromising look, but must not be condemned because it resembles at first sight one attempt at the chimerical and impossible "perpetual motion."

Fig. 57.



Calles's Aëro-hydro-dynamic Wheel.

It is one mode of transmitting power by means of condensed air.

The following is from the Journal of the Society of German Engineers, and describes the apparatus represented in the cut, the invention of M. Calles of Belgium: —

"It consists mainly of a wheel adapted with buckets similar to those in an ordinary water-wheel, and completely immersed in a tank filled with water. This wheel carries a toothed inner rim, which works a pinion adapted to the transmission-shaft.

"Most transient visitors to the Paris Exposition, as they walked past this contrivance, hardly gave it a look, believing that it was the pinion that gave motion to the wheel, and considered it as some sort of stirring or washing machine; but the inverse was in reality the case, as it was the immersed wheel which gave motion to the pinion by the direct action of slightly compressed air.

"The general disposition of parts will be readily understood by reference to the diagram: —

"The diameter of the wheel exhibited was 9 feet; its breadth 4½. It carried 30 buckets, curved in such a manner that 13 of them (figured to the left) always retained a certain quantity of air in their upper portion.

"The air was introduced under the bottom of the wheel, through a curved pipe. The air thus blown into the buckets had naturally a tendency to gain the surface of the water with a force equivalent to the weight of displaced water, and this upward tendency caused the rotation of the wheel, and at the same time brought back the discharged buckets successively before the orifice of the tuyere.

"The wheel made six revolutions per minute, so that three buckets were filled with air every second.

"The air rushed with a velocity of 32 metres per second through a pipe 0.095 metres in diameter. The quantity discharged was consequently 0.227 cubic metres per second, equivalent to 0.075 cubic metres for each bucket or cell. During every second of time, 13 buckets were thus partly filled with air, their total capacity being 0.983 cubic metres. The same bulk of water being displaced, a constant power of approximately 983 kilogrammes, or 2,163 lbs., per second was obtained.

"The internal diameter of the wheel being 2.26 metres, its annular surface 3.05, and its width 1.5, it is readily computed that the 30 buckets occupied a space of 4.585 cubic metres, and that each cell cubed 0.153 cubic metres, — a portion of which space, equivalent to one half, or to 0.075, alone contained air.

"If the application of force be supposed to have been applied at one quarter of the depth of the wheel under water as an average, then the speed of any point of its surface would have been $2.445 \times 6 \times w \div 60 = 0.77$ metres = 30 inches.

"Multiplying this speed by the 983 kilogrammetres, we find the power transmitted per second to have amounted to 757 kilogrammetres. If we deduct herefrom 20 per cent for losses by friction, reaction of water, etc., there remain 606 kilogrammetres, or 260,000 foot-pounds, as available working-power per minute, — equivalent to an 8-horse power.

"The forcing of the air was effected by means of a 9½-horse steam-engine, — the compression of the air being one quarter of an atmosphere. In the example exhibited, 83 per cent of the power of the engine was thus transmitted to the wheel, and this through a pipe 510 feet long and presenting 14 elbows.

"The above-described new method of transmission of motion may prove of very great value in many situations where the application of belts and shafting, parallel motions, such as are used in mines, and other similar contrivances, is impracticable. It might also be applied with success to the driving of machinery in cities for the smaller branches of industry, — the compressed air in such a case being conveyed through mains and pipes laid below the surface of the streets in the same manner as is at present practised for our water and gas supplies."

By reference to WIRE ROPE, several instances may be found where power is transmitted to a distance much beyond what is possible with belting or shafting, the ordinary expedients. In one case, at Frankfort on the Main, the power is thus transmitted 3,200 feet. In a second case, at Schaffhausen, in Switzerland, the power of a number of turbines, amounting in the aggregate to 600-horse power, is transmitted more than a mile, crossing the river Rhine to the place where the power is to be distributed.

Machinery in mines and tunnels is frequently driven by the power of compressed air, which is condensed into a reservoir by steam or water power on the surface of the ground, and conducted by pipes to the deep-seated spot where the drill or mining-machine is at work.

"At Mont Cenis the air-pipes must be as much as five miles in length, and the loss of pressure is not such as to impair the working of the drills; but I am without accurate information as to its extent. At Hoosac they are one and a half miles long, and the loss is two pounds to the square inch. At Nesquehoning they are one third of a mile in length, and there is no appreciable loss of pressure. In this case the air is worked at about fifty pounds per square inch; and the difference in pressure at the steam-valves, when the power is generated, and the air after it is compressed, may be taken at about ten per cent when the best compressors are used. It will then be seen that the loss of power from the friction of the compressing machinery, and from the movement of air in the pipes, is not of a very serious character, and, if the pipes are tight, the pressure is well maintained while the machinery is standing." — *Steele.*

"The compression of the air by which the drills at the Hoosac Tunnel are driven is effected at the east end of the tunnel by water-power; four 20-horse turbines being employed, which operate sixteen air-pumps, each of 13½-inch bore and 20-inch stroke.

"The air is compressed to 65 pounds to the square inch, or a little over four atmospheres, and conducted through an 8-inch east-iron pipe to the drills at the tunnel heading, where branch pipes connect several drill-cylinders with this 8-inch pipe. With six of the drills at work and making 250 strokes per minute, the gage on the air-pipe at the heading of the tunnel shows a pressure of 63 pounds against 65 pounds at the pump-rooms, one mile and a half distant."

"The engineers of the Mont Cenis Tunnel have expressed themselves strongly in favor of the view that the plan is truly economical, and as their experience in the use of this form of applying power has been larger than any which has been elsewhere enjoyed, their statements deserve consideration. At the date of the report on the progress of the work in the tunnel during the year 1863, they were engaged at a distance of nearly two thousand metres from their reservoirs of condensed air, and were driving nine borers with a force of 2½-horse power each. The tube conveying the air to the perforators was two decimetres (nearly eight inches) in diameter. The air was under a pressure of six atmospheres, and its velocity in the tube was nine decimetres (three feet) per second. The transmission of the power to this distance, and under these conditions, was attended with no sensible loss. The pressure was not perceptibly less at the working extremity of the tube when all the perforators were in operation than when the machinery was entirely at rest.

"A series of experiments was instituted in 1837, by order of the Italian government, to determine the resistance of tubes to the flow of air through them. These experiments were made previously to the commencement of the work upon the tunnel, and while the feasibility of employing compressed air to furnish the motive-power of the boring apparatus was considered still questionable. It was the aim of the investigation not merely to ascertain the absolute loss of force occurring in the transmission of air through tubes of certain particular dimensions, but to determine, if possible what are the

laws which govern the variations of resistance, when the velocities of flow and the diameters of the tubes are varied. From the results of the experiments were deduced the three conclusions following, namely, —

"I. The resistance is directly as the length of the tube.

"II. It is directly as the square of the velocity of flow.

"III. It is inversely as the diameter of the tube." See *Report of Dr. Barnard, United States Commissioner at the Paris Exposition.*

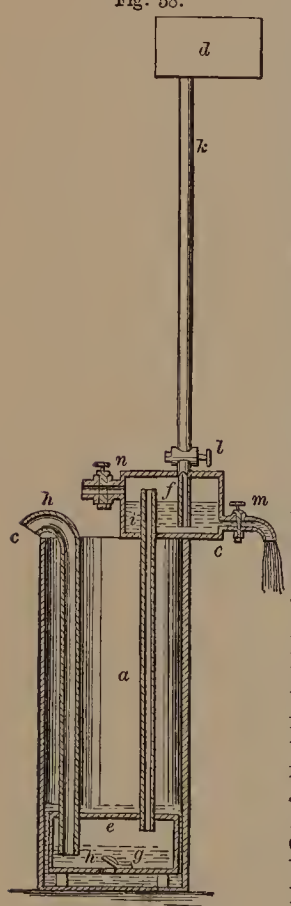
This great work is happily completed. See TUNNEL.

In the Verpilleux pump, water is made the means of transmitting power. See FORCE-PUMP.

The transmission of power by means of compressed air has now become an established fact, notwithstanding the clear decision which was rendered against it, from the supposed nature of the case and the principles involved. Its use in the Hoosac and Mont Cenis Tunnels in driving the boring-machines is referred to under TUNNEL. Its use in the Govan Colliery, Scotland, is referred to under AIR-COMPRESSING MACHINES. See also AIR-ENGINE, COMPRESSED. Its use as a liquid elevator is considered in the next article.

Air as a Water Elevator, Compressed. The first attempt to raise water by the pressure of a body of compressed air, so far as our present information extends, was that by Dr. Papin, of Blois, France, about 1695. His experiments were particularly directed to utilizing the power of a fall of water in compressing air which was conveyed a mile or more to a cylinder at the mine, where it was intended to work a pump by reciprocating a piston in the manner of a steam-engine. The experiment failed, as has been already stated (see AIR AS A MEANS OF TRANSMITTING POWER), but has since been successful in operating rock-drills at Hoosac Mountain, Mont Cenis, and many other places.

Fig. 58.



Chemnitz Water-Elevator.

It does not appear that Dr. Papin tried the direct pressure of a body of air upon the water; in a manner similar to the pressure of steam upon the surface of the water in the *so-called* steam-engines of Baptista Porta, 1600; De Caus, 1620; Marquis of Worcester, 1655; Savery, 1698. See STEAM-ENGINE.

For many years past — probably a century or more — water-elevators operating by condensed air have been used at the mines of Chemnitz in Hungary. A high column of water is used to condense a column of air in a pipe, so that the power of the apparatus is proportioned to the vertical height of the fall which is available. In the mountainous districts of Central Europe some remarkable falls are thus utilized, some of which are referred to under TURBINE. In the Black Forest of Baden turbines are running with falls of 72 and 354 feet, and having diameters of from 20 to 13 inches respectively.

In the figure, the vertical elevation is out of all proportion small, but the principle involved is not affected thereby. It should be understood that the height of the fall above the surface of the ground should be as great as the depth below the surface of the ground of the water to be elevated. If the fall be in excess of the lift, so much the better.

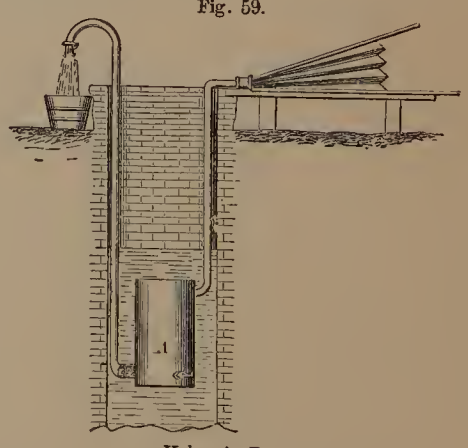
a is the shaft of the mine, and *c* the surface of the earth; *d* is the penstock of the water at the top of the fall, and *k* the pipe which leads the water to the air-tight box *f* at the surface of the ground. The closed box *f* communicates by an air-pipe with the air-tight box *c* which is submerged in the *sump-hole* at the bottom of the mine. The eduction water-pipe *h* has its lower end submerged in the water of the box *e*, and conducts the water to the surface *c* when the apparatus is in action. A cock *l* in the fall-pipe *k* is closed or opened as the alternating to be described requires. The box *f* has also cocks at *m* and *n*, and the box *e* an inlet valve *g* on its bottom.

The operation is as follows: —

The cocks *l* and *m* being closed, the cock *n* is opened to allow the air to escape from box *e* and the water to flow thereinto by the valve-way *g*. The cock *n* is then shut, the water-cock *l* opened, when the column of water in the pipe *k* will fill the chest *f*, expelling the air therein and driving it down the pipe *i* into the box *e*, expelling the water therefrom to a certain extent, that is, until the pressure of the condensed air in the box *e* is equalled by the weight of the vertical column in the discharge-pipe *h*; which should have a valve at its lower end opening upwardly. The cock *l* is now closed and the cock *m* opened, allowing the water to run out of the box *f* and the air from *e* to fill box *f*, while water enters the lower box by valve-way *g*. The cock *m* being closed and the cock *l* opened, the air is again forced from *f* into *e*, repeating the process just described.

An early example of raising water by the dejection of a condensed body of air is the patent of UPHAM, January 6, 1809, of which the annexed cut is an illustration.

Fig. 59.



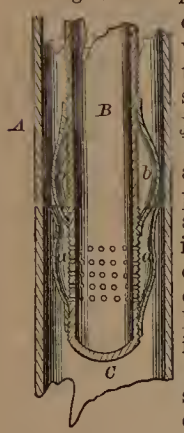
Upham's Pump.

Pressure on the bellows injects a body of air into the chamber *A* in the well, and drives a body of water from thence through the eduction-pipe which leads to the discharge above the surface of the ground. When the bellows is raised, the valve at

the foot of the eduction-pipe closes and water enters the chamber by the induction-valve. The repetition of the motion again ejects water, and so on. The required degree of pressure in the air-chamber is attained by means of an air-valve in the bellows; after that, if the level of the water remain the same, the same body of air is made the agent, by its vertical pulsations, of ejecting the water.

The use of compressed air in forcing liquids from deep wells or shafts has received a great accession from the oil enterprises in Western Pennsylvania and other places.

Fig. 60.



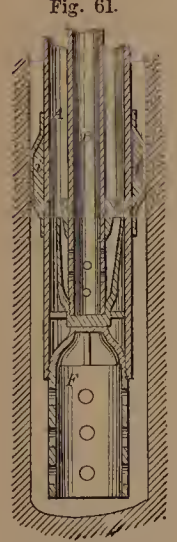
Mowbray's Ejector.

Perhaps as many as fifty patents have been granted for various forms of EJECTORS, the different forms of which will be considered under that title. These are founded on the same principle as the Giffard injector, which is a favorite device for boiler supply. In the ejectors an annular stream of fluid under compression (air or steam) is emitted around an axial nozzle communicating with the liquid to be moved; or, conversely, a central stream of compressed fluid to propel a film of liquid through an annular opening.

In the deep oil-wells, which consist of a vertical shaft of a few inches' diameter and several hundred feet depth, it is advisable to have all the apparatus included within a single tube as in the two following cases:—

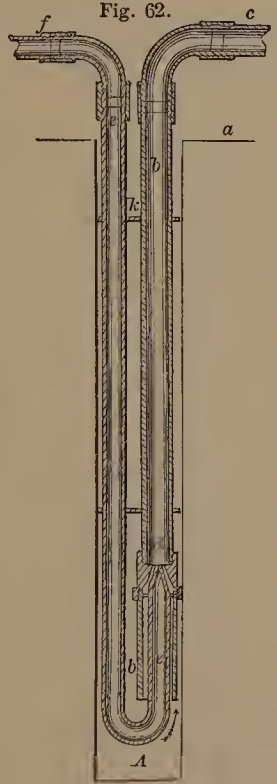
MOWBRAY, December 13, 1864. The current of compressed air from the engine above descends the middle pipe *B*, and is emitted at the annular opening between the cup *a* and the bulb *b* on the central pipe. The area of the annular opening is adjustable, and the effect of the emission of the stream of compressed air is to draw up the liquid from the space *C*, and elevate it to the surface through the space intervening between the tubes *B* and *A*.

Fig. 61.



Angier and Crocker's Ejector.

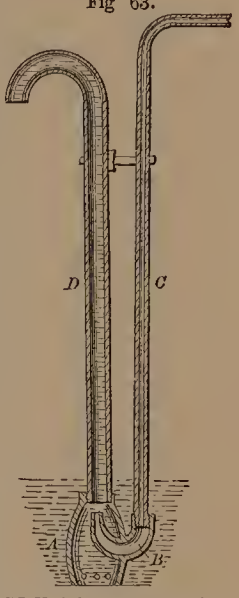
Fig. 62.



Angier and Crocker's Ejector.

ANGIER AND CROCKER, December 13, 1864, have a device for the same purpose. Fig. 61 shows a section of the well in which the seed-bag *i* (see WELL-TUBE PACKING) is shown. Its purpose is to prevent the descent of the water from above to the bottom of the well whence the supply of oil is drawn. The bulbous deflector and encircling cup are arranged for action as described in the preceding case. *B* is the air-descending, *A* the oil-ascending space. *F* is a perforated tubular foot for the well-tube.

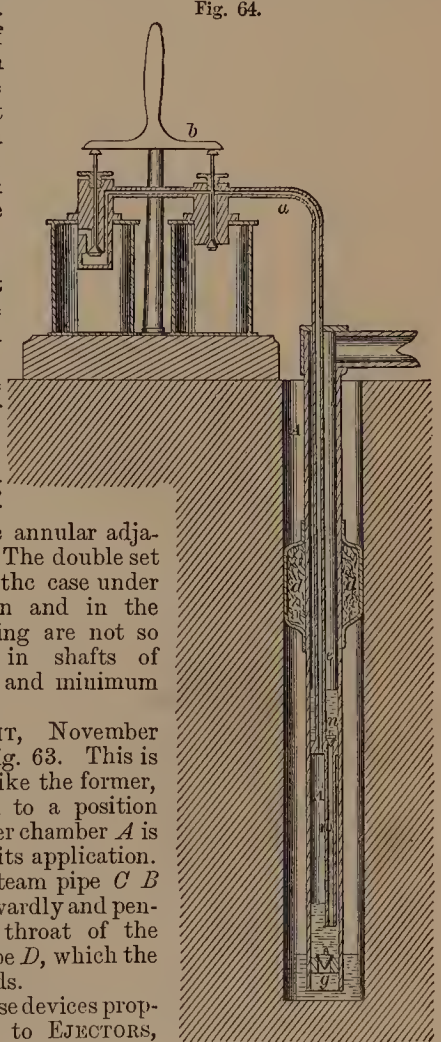
Fig 63.



McKnight's Water-Raiser.

ANGIER AND CROCKER, October 11, 1864. Fig. 62. The current of compressed air passes down the tube *f e*, whose lower end is recurved upwardly and ends in a small orifice at which the air is emitted. As the air passes through the throat *d* into the pipe *b*, it tends to produce a partial vacuum in its rear, and draws an annular film of water with it from the space *A* at the bottom of the well. The action is the same as in the former case, except that in this the moving fluid is a jet central to the film of water moved by it, and in the preceding cases the air and oil were annular adjacent films. The double set of pipes in the case under consideration and in the next following are not so convenient in shafts of great depth and minimum diameter.

Fig. 64.



Pease's Oil-Ejector.

MCKNIGHT, November 1, 1864. Fig. 63. This is an ejector like the former, but adapted to a position where a lower chamber *A* is not fatal to its application. The air or steam pipe *C B* recurves upwardly and penetrates the throat of the eduction-pipe *D*, which the water ascends.

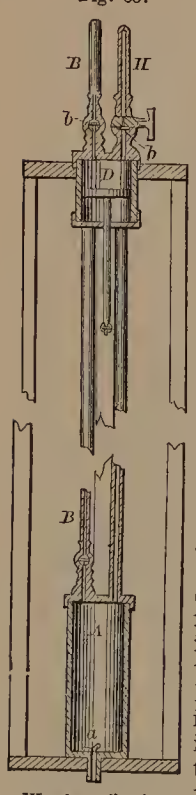
While these devices properly belong to EJECTORS, which are considered at

greater length under that title, it will be useful to give a slight sketch of the modes of utilizing the compressed air, the subject-matter of this article.

The ejectors described are direct-acting and the pressure continuous. It remains to cite one or two employing the pulsative or alternate action of air. This is accomplished by alternate pressure and exhaust, and is claimed to be very effective.

Pease, March 28, 1865. The current of air is made to oscillate in the downcast tube, acting like an elastic piston in its effects upon the contents of the chamber *A'*, which is placed low down in the well *A*. Fig. 64. The upper end of the pipe is connected alternately with two cylinders, in one of which is a body of compressed air, while in the other is a partial vacuum; the exhaust and pressure of the respective vessels being effected by an air-pump. The rock-bar *b* is oscillated on its pivot, and acts alternately upon the valves, bringing the pipe *a* in connection with the pressure and exhaust in turn, and giving the pulsative movement to the column of air in the pipe. As the air rises therein, the induction-valve *g*, at the foot of the chamber, lifts and admits oil from the well to the chamber *A'*, and as the column of air descends, the said valve closes and the oil is raised through the pipe *m*, the valve *n* rising to allow it to pass to the upward discharge-pipe *e*. The seed-bag *d* acts as a packing between the exterior pipe and the wall of the well, and prevents access of water from fissures to the water, oil, or brine at the bottom of the well.

Fig. 65.



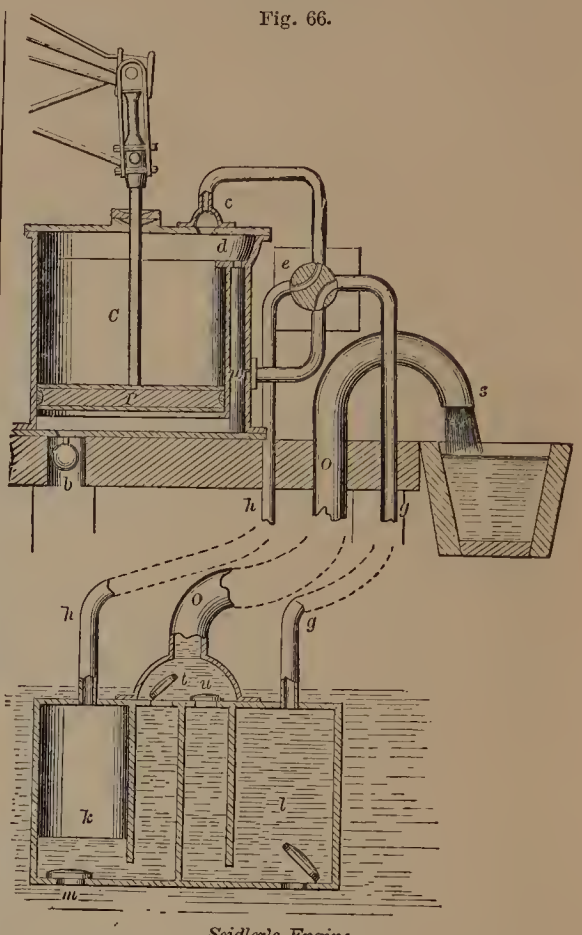
Woodward's Air-Pump.

Woodward, May 30, 1865. The piston reciprocates in the air-cylinder, and by adjustment of the valves *b b*, is the means of exhausting from the chamber *A* or of forcing air into the said chamber. As the air is withdrawn, the chamber is filled by the induction-pipe, the valve *a* opening for that purpose. When the air is compressed into the chamber, the water is ejected by the pipe *B*. The action is not pulsative, as in the preceding case, but is alternate by the operation of the same cylinder and piston, and is effected by changing the position of the cocks *b b*.

A Hydraulic Engine, so called, patented in England by Seidler some forty years since, may be classed among the alternate-acting water-elevators operated by compressed air. The construction will appear by reciting the series of operations when it is in action. Supposing the piston *P* to commence its upward stroke, the air in the cylinder *C* will be driven through the valve *e* in the upper head and by means of the pipe *h* into the submerged vessel *k*, forcing the water contained therein through the valve-way *t* and by means of the eduction-pipe *O* to the discharge-chute *s*. Air will be supplied to the cylinder below the piston by the opening of the valve *b*.

When the piston descends, the air will pass from the lower to the upper side of it by means of the valve *d*, and the operation will be continued till the water is driven out of *k*, when the two-way cock *e* will be turned to change the communication; the air then passing by pipe *g* to the tank *l*.

Fig. 66.



Seidler's Engine.

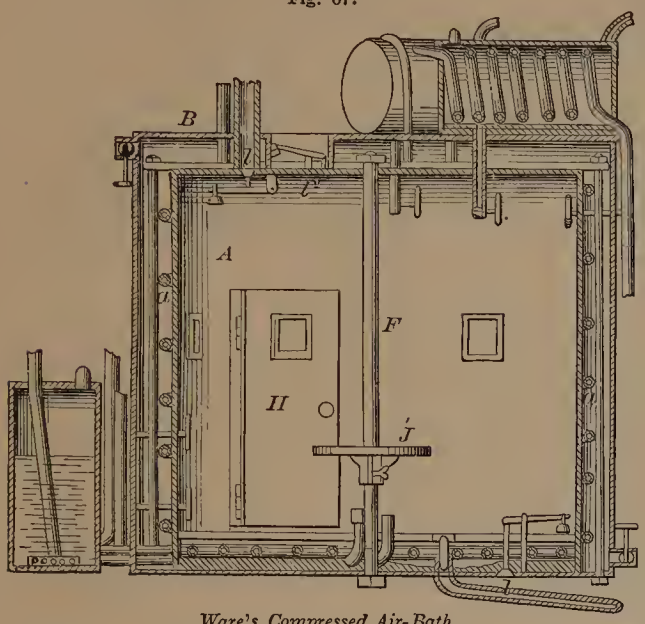
The air which was forced into *k* is permitted to re-enter the cylinder through the pipe *w*, as shown by the dotted lines in the cock *e*, so that no air will be required to enter at the valve *b* except at the commencement of the operation, or to make up for any air lost by leakage or discharged with the water. When the air is liberated from the tank *k*, it is again filled with water by the valve *m*, the valve *t* being shut by the pressure of water in the pipe *O*. While this is proceeding, the water is being discharged from the tank *l* by the valve-way *u* into the pipe *O*, as before described in relation to the tank *k*. The cock *e* is turned by hand or by machinery, after such a number of strokes as may be sufficient to empty a division of the tank.

Air'-bath. A therapeutic apparatus for the application of air to the body, in a jet or chamber, locally or generally, refrigerated or heated.

The compressed-air apparatus is the reverse of the vacuum appliance, which proposes to increase the surface secretion and local circulation by exhausting air; an operation analogous to *dry cupping*. See Depurator.

Ware's Compressed Air-bath is for subjecting a patient to an enveloping atmosphere of air under pressure. The chamber *A* has a non-conducting outer wall *B*, and a metallic inner wall, the intervening space being occupied by coils of pipe *a*, which may be steam-heated. A safety-valve in the floor limits the pressure. *H* is the door of entrance, which shuts air-tight. The patient has command of the air and steam valves by which the chamber is charged and the steam-coil heated. *J'* is a seat, *F* a tie-rod, *l* an eduction water-pipe.

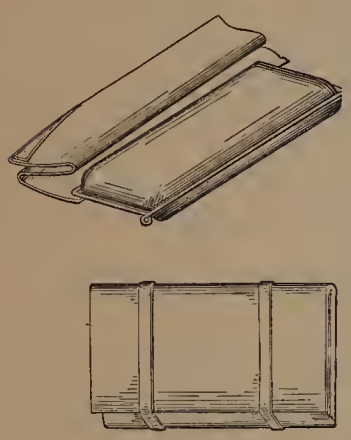
Fig. 67.



Ware's Compressed Air-Bath.

Air-bed and Air-cush'ion. These were known in the beginning of the eighteenth century, and were at first made of leather and afterward of air-tight or Mackintosh cloth; at present they are made of vulcanized india-rubber. The bed is a sack in the form of a mattress, divided into a number of air-tight compartments, and having a projection at one end forming a bolster; each compartment has a valve through which it is inflated by a bellows. Air-cushions are merely small sacks filled with air through a tube at one corner or end, by means of an air-condenser or by expiration from the lungs: escape is prevented by a screw-stop-cock. These articles are useful to travellers and invalids, being light and elastic, but are liable to be torn or punctured, and thus rendered worthless.

Fig. 68



Linden's Air-Bed.

Linden, October 7, 1862, has adapted the elastic bed to be used as a part of the infantry equipment. The air-bed has an outside flap of enamelled cloth or leather, cut longer and wider than the bed so as to form a coverlid for the person who lies upon the inflated bed. When the bed is collapsed it can be folded in such a manner as to form a knapsack, and is provided with straps to enable it to be worn as such when on the march.

Hamilton, July 16, 1867, ties the upper and lower surfaces of the bed, of air-proof material, by means of cords which are secured to button-headed screws and cap-nuts, which clamp the material and make the joint air-tight.

Gilbert, February 11, 1868, stuffs the beds with elastic, hollow spheres of rubber. The same device was employed by a patentee in England, whose bed is described in the English Cyclopædia, London, 1859. It was found to be too expensive for general use. An inflated air-bed is shown under Bed; copied from a German work of A.D. 1511.

Air'-blast. See Blower.

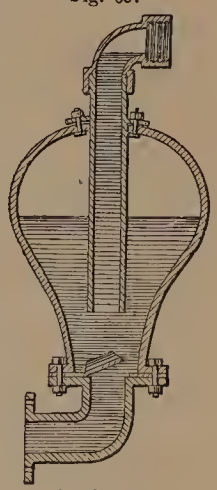
Air'-brick. An iron box made of the size of a brick, and having a grated side. It is built into a wall, and forms a ventilating opening.

Air, Car'bu-ret-ing. See Carbureting Gas and Air.

Air'-cas'ing. A sheet-iron casing around the funnel on board a steam vessel, to prevent the transmission of heat to the deck.

Air'-cham'ber for Pumps. This was used by Dr. Papin of France about 1695, but had been described nearly two thousand years previously by Hero in his "Spiritalia." It was attached by Perrault, in 1684, to the fire-engine (*Pompe Portative*) of Duperrier.

Fig. 69.



Air-Chamber.

It is intended to equalize the flow of water from a reciprocating pump. The action of the pump being intermittent, the tendency is pulsative and the delivery in jerks. The body of air confined in the upper part of the chamber forms an elastic cushion against which the water impinges when lifted; when the pump-piston stops to commence its return movement, the air again expands and continues the flow of water during the interval of inaction of the piston; the valve falls as soon as water ceases to enter the chamber, to prevent return of the water by the induction-pipe, when the air expands.

Air'-com-press'ing Ma-chine'. A machine adapted to condense air as a motor, or for ventilation in shafts and mines. For this purpose air is particularly well adapted, because its exhaust in the mine shaft or tunnel affords a direct means of ventilation by supply of vital air at the point where the work is under way. The works at the Mont Cenis and Hoosac Tunnels are notable instances of the use of compressed air carried to a great distance. The air-compressing engine of Sommeilleur at Bardonneche worked the rock-drills at the Italian end of the Mont Cenis Tunnel, and was operated by the displacement of air from a pipe by a heavy column of water obtained from the hills. See Compressed-air Machine; Tunnel. The escape of steam at the point of work is not so desirable as that of air for two reasons: the condensation of the former prevents its acting to produce an outflow of air towards the mouth, as is produced by the escaping and expanding air; and it only adds to the dampness and obscurity of the usually wet shaft or drift, instead of being a source of supply for breathing, from the healthy region of the exterior air.

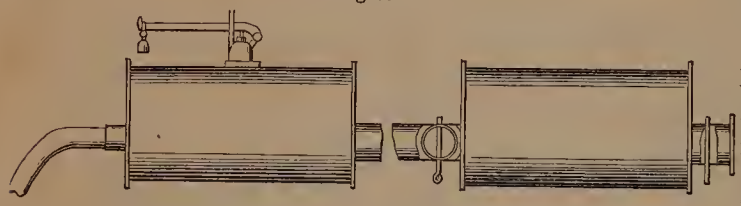
Many of the devices for merely assisting ventilation are no more than blowers (which see), but for use as a motor a more positive condensation is required. By the law of Mariotte, the elastic force of air varies in the proportion of its density; the greater the pressure the smaller the volume. Assuming the natural pressure to be 15 pounds to the square

inch, by reducing the volume to one half we shall have a pressure of 30 pounds to the square inch; to one quarter, 60 pounds; to one tenth, 150 pounds; to one fortieth, 600 pounds.

The stroke of a piston in its cylinder, therefore, if it reduce a body of air to one twentieth its original volume, will subject it to a pressure of 300 pounds to the square inch. The air is generally allowed to escape by a valve-way before the approaching piston, and is collected in a reservoir, whence it passes to the machinery where its expansive force is to be applied. The circumstances of position and use are so very varied that no general statement of its mode of application will apply. Sometimes it is stored in reservoirs at the point where it is used as a motor or a ventilator.

Fisk and Waterman, January 17, 1865. The reservoirs for compressed air are located within the mine, and connected by comparatively large induction-pipes with the air-forcing pump at the mouth of the mine. The object is to exert a uniform pressure at the working point, where compressed air is used as a motor, and to prevent a stoppage of the ventilation during a temporary stoppage of the compressing-engine at the mouth of the mine. The

Fig 70.

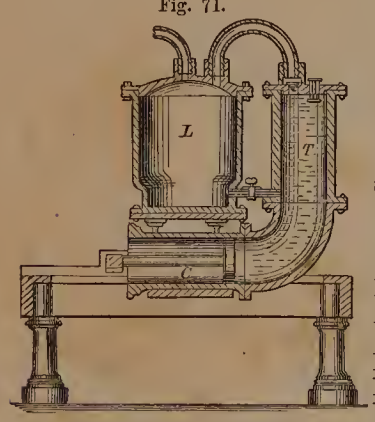


Fisk and Waterman's Compressed-Air Reservoir.

eduction-tubes by which the air is discharged from the reservoir are of comparatively small diameter, and are provided with stop-valves.

Holly, May 22, 1866. Water is urged by the piston *C* and forced through the curved pipe into the reservoir *L*. As the piston recedes, the valve in the head of the air-cylinder *T* is opened, to supply the cylinder with air. Water collecting in the reservoir is passed by a pipe to the cylinder *T*. Water between the piston and the air permits a water-tight instead of air-tight packing to be used, the air re-

Fig. 71.

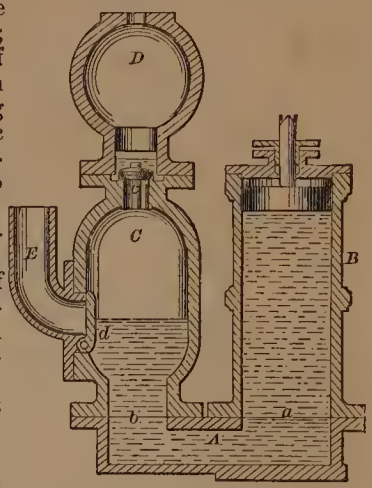


Holly's Air-Compressing Pump.

treating before the column of water at each forward stroke of the piston and following it during its return stroke.

Ransom, August 8, 1865. The two cylinders are connected at bottom by a hollow bed-plate *A*, and have a constant amount of water, which is made the intermediate between the piston in the cylinder *B* and the air which occupies cylinder *C*. As the piston descends, the column of water rises in cylinder *C* and ejects the air, which passes through the valve-way *c* into the dome *D*, the pressure closing the valve *d*. As the piston is raised, the water retreats, the valve *c* closes, valve *d* opens and admits air by the duct *E* to the cylinder *C*. The motion is repeated; the intervention of the water, as in the last-preceding case, obviating the necessity for an air-tight packing to the piston.

Fig. 72.

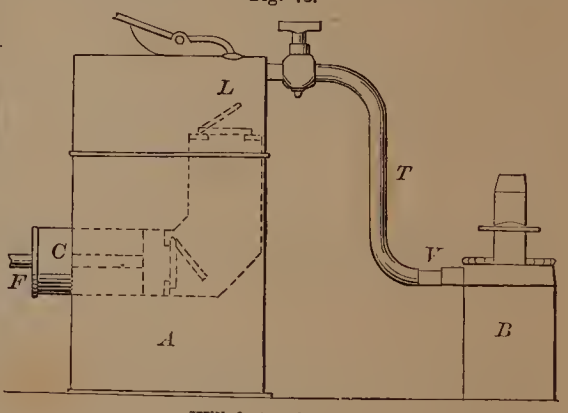


Ransom's Air-Compressing Pump.

Wilhelm, December 26, 1865. A pump *C F*, of ordinary construction, is enclosed within a large air-chamber *L*, which has no bottom, but is suspended in an open vessel of water *A*, so that the water may rise high in the chamber, and when driven back by the force of the air may continue a pressure thereon and thus keep up a continuous blast. This may be better adapted for a blower, but, by arranging for a high vertical column of water, it may be applied to more positive and high-pressure purposes.

Patric, April 18, 1865. This device is intended to be placed at the foot of a waterfall, the water acting in alternate compartments *E*, *E*, which are separated by a flexible diaphragm connected to an adjusting-bar *b*, that operates the inlet and outlet water-valves *e a* of each chamber. When either compartment is emptied of the water contained therein,

Fig. 73.



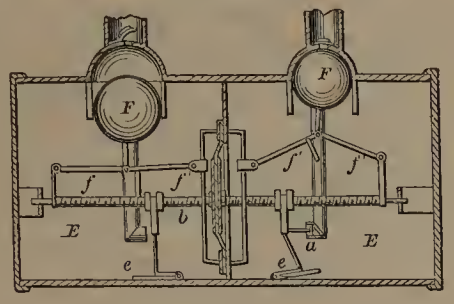
Wilhelm's Air-Pump.

an air-valve is opened and the air rushes in and fills the space vacated by the water, when, at the proper time, by the action of the floats *F*, and levers *f f'*, acting upon the diaphragm, the inlet-valve is opened, the water enters by virtue of its gravity, and the air is compressed and forced out of that compartment to a suitable reservoir, where it is reserved for use in any suitable engine.

The efficient force depends upon the height of the column of water, and the consequent force with which the air was ejected by the water which displaced it.

Jameson, March 13, 1858. The air is compressed (or rarefied by the inversion of the process) by the successive action of pistons in cylinders connected

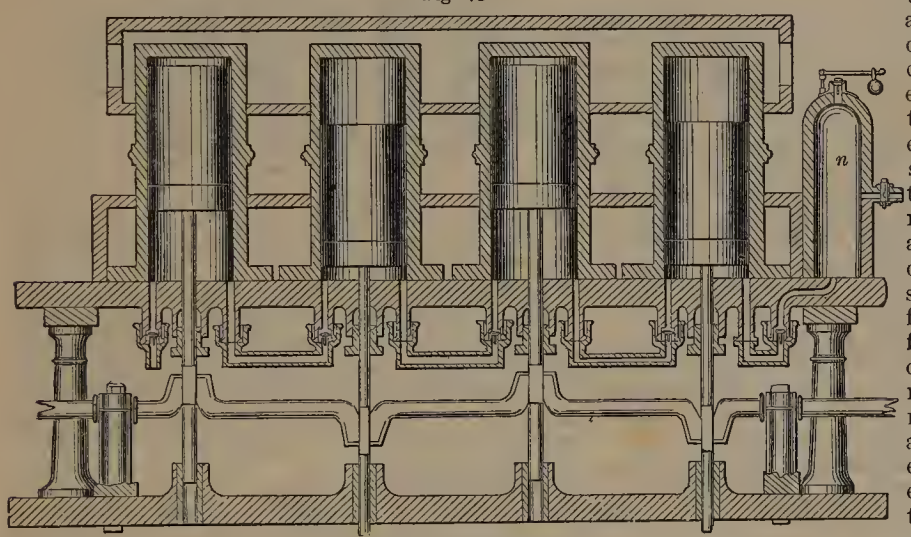
Fig. 74.



Patric's Air-Compressor.

by pipes, whose valves govern the direction of the flow. Each piston is connected to a crank on the common rotary-shaft beneath. As the air passes from one to the other, it receives an additional condensation, and is eventually stored in the reservoir *n*, at the end of the series ; from thence it is drawn, as required, to act as a motor, a blast, or for any other purpose for which it is adapted. The cylinders are enveloped by passages where a heater or refrigerant may be placed to act upon the air. Air develops sensible heat as its volume is diminished by compression, and if it be used for cooling purposes, as in ice-making, its preliminary cooling before it is allowed to expand will make it more effective in absorbing sensible heat when freed.

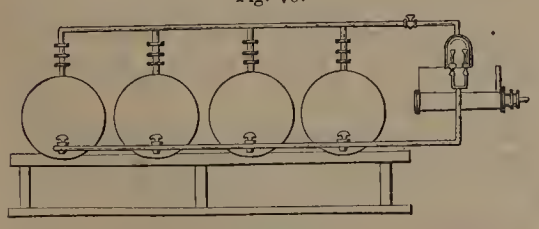
Fig. 75.



Jameson's Air-Compressor.

Arthur, July 25, 1865. An air-pump is combined with a series of air-vessels by means of pipes and stop-cocks, or valves, in such a manner that the air compressed into one air-vessel may be used to supply the pump when compressing air into one or more other air-vessels to a higher tension, the air entering the pump-barrel being thus already compressed to a certain tension. The amount of increase in tension which the pump is required to produce need not exceed that at which it will work advantageously. In the last reservoir in the series the air is further compressed by forcing water into the lower part thereof by means of another pump. The air is compressed more and more by the successive operations, a single pump being required. The pump is connected to such one of the reservoirs as may be required, and discharges into another or others, the power required to work the pump being only the difference between the pressure in the two.

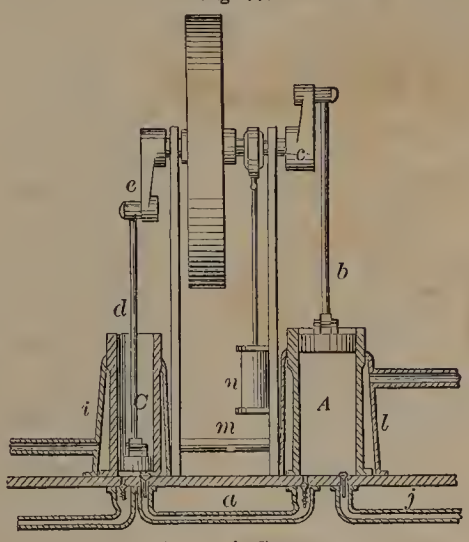
Fig. 76.



Arthur's Air-Compressor.

Dennison, October 23, 1866. The pistons are attached to cranks set at 180° on the same shaft, and reciprocate in cylinders of varying diameters, the larger having an air induction-pipe, and discharging into the smaller, which has an eduction-pipe. A water-jacket keeps the parts cool. By this means the air receives a double condensation ; the difference between the sectional areas of the cylinders is such that in each a similar amount of power is exerted. The induction and eduction pipes of the single-acting cylinders are provided with valves which govern the direction of the air, opening and closing automatically. The pipe *B* conducts water to the jackets around the cylinders, to remove the heat evolved by the compression of the volume of the air. The pipe *C* removes the water. The abstraction of heat, of course, lessens the pressure. This is desirable for some purposes, not for others. Hot water or steam, acting in the reverse direction to a refrigerant, would be adapted to increase the effect of the air as an expansive motor. Alternate expansion and contraction was the whole principle of the M. I. Brunel Gas-Engine Patent, England, 1804.

Fig. 77.



Dennison's Air-Compressor

Heated carbonic-acid gas is preferable to air for developing a large force in small space. See GAS-ENGINE. See also AIR-ENGINE; COMPRESSED-AIR ENGINE; AIR AS A WATER-ELEVATOR.

Air'-cone. In marine engines; to receive the gases which enter the hot-well from the air-pump, whence, after ascending, they escape through a pipe at the top.— ADMIRAL SMYTH.

Air'-cool'ing Ap'pa-ra'tus. In this article will be considered the devices for cooling a current of air, for purposes of health and ventilation, and not those involved in producing anæsthesia by cold, the manufacture of ice, or the cooling of fruit and meat chambers. These will be considered under their appropriate heads. The purpose of the former two of these is to reduce the temperature below the freezing-point, and of the latter to reduce it nearly to that point, while for purposes of ventilation the aim is to reduce to a moderate degree the passing volume of air which escapes and gives place to that which is following.

The circulation is not a necessary incident to ice-making or to the fruit-house, though in the latter there is no doubt that circulation of air is a valuble feature in retaining the purity of the atmosphere in the chamber.

Another large class of inventions in which an artificial blast of cold air is employed is the beer and liquid coolers, which are of three kinds: those in which an artificial blast is driven through the arms of the stirrer to cool the contents of the mash-tub; those in which the liquid is passed through a refrigerating vessel and is cooled by contact therewith; those in which refrigerating effects are imparted to a vessel containing liquor on draft, to reduce its tendency to fermentation or to make it more palatable. See LIQUID-COOLER; ICE-MANUFACTURING; ANÆSTHETIC APPARATUS; FRUIT AND MEAT CHAMBER.

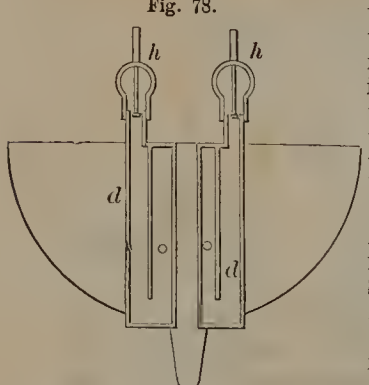
The East Indian Tatta is a screen of finely woven bamboo in a frame which fits into a window-opening. It is kept constantly moist by trickling water, and thus cools the air as it enters the apartment, while the screen also excludes insects.

The same effect is produced by an arrangement which keeps moist the mosquito-bar around the bed.

The Alcaraza is a Spanish form of the same device.

SOMES'S plan for ventilating ships, February 28, 1865. The design of the apparatus is to expose a current of air to contact with vessels or pipes filled with water taken from a distance below the surface. The system of pipes is arranged at any convenient submerged point on the ship's sides, and the air is forced in contact therewith by the motion of the vessel, or the action of the waves. The cooled air is conducted by pipes to cool and ventilate the various apartments in the vessel, or the grain or other perishable freight with which it may be loaded.

Fig. 78.



Somes's Ship-Ventilator.

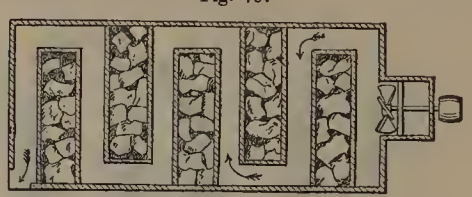
See also THIERS'S AMERICAN PATENT, 1871. See SHIP-VENTILATING.

In SOMES'S plan for ventilating, cooling, and heating the Capitol, the air is introduced into a vault so far beneath the surface as to be free from the changes of temperature incident to the seasons. The air is conducted by a conduit, in which it is exposed to pipes whose contents have a warming or refrigerating effect upon the passing air. Purifying and moistening influences are also brought to bear upon the air.

In his patent of October 15, 1867, vacuum and compressing chambers are used in combination with the pumps which create the current of air. Atomizing tubes are added to reduce the temperature and impart moisture, the disseminated liquid becoming vaporized and absorbing free caloric from the air. Another plan is to force a body of air through pipes which pass to the cold earth below the surface, or to expose air to the contact of pipes filled with water which has been conducted to the said depth. It is suggested, in connection with this, that the air may be condensed in the cooler and become further cooled as it expands.

SHALER'S air-cooler, May 30, 1865. The case contains a series of cells so arranged as to form a tortuous passage. The chambers are filled with ice, and the air is caused to circulate through the passage by means of a fan.

Fig. 79.

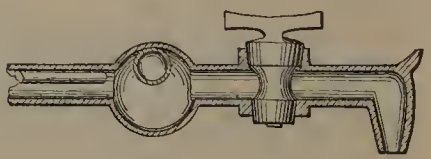


Shaler's Air-cooling Apparatus.

In MAINE'S apparatus for cooling and disinfecting air, December 4, 1866, a continuous apron of porous material is passed through the tank containing the disinfecting and cooling liquid, and thence passes over rollers rotated by clock-work, its surface being exposed to a current of air, generated by a fan which is driven by the same motor as the rollers. See Air-FILTER.

Air'-cush'ion for Pipes. The object is to avoid the jar which occurs when a column of water in motion is suddenly arrested. Various means have been tried, prominent among which are air-chambers. Air, however, is gradually absorbed by the water, and as a means of imprisoning it and still allowing it to contract when the jar comes, and afterwards to expand, it is enclosed in a ball of india-rubber. This is shown in BEVAN'S patent, March 14, 1865, and in some others. The arrangement also allows the expansion of the water, in freezing, without bursting the pipe. The sack is placed in an enlargement of the pipe, and so caged as not to stop the flow. A continuous tube of the same material, and containing air, is arranged in the tube also.

Fig. 80.



Bevan's Air-Cushion for Pipes.

Air'-drain. (*Building.*) A cavity around the subterranean walls of a building, protected by a wall on the earth side, and designed to prevent the absorption of moisture by the wall.

Air'-drill. A drill driven by the elastic pressure

of condensed air. The construction usually resembles the reciprocating steam-engine, compressed air being substituted for the steam; the drill-stock is attached to the piston-rod. It is usually termed the PNEUMATIC DRILL, which see.

Air'-en'-gine. For more than a century the attention of mechanicians has been directed to means for making air and gases available in driving machinery. The inventions resulting from these efforts have led in different directions, or to different sets of specific means.

AMOUTON (France, 1699) had an atmospheric fire-wheel, or air-engine, in which a heated column of air was made to drive a wheel. A smoke-jack is a familiar instance of the same on a small scale. So are the toys now attached to stove-pipes and representing incipient men (monkeys) sawing wood, etc.

Some have attempted to make available the expansion of air, previously mechanically condensed and stored in reservoirs. It was not understood, apparently, that the valuable effect would only be equal to the force employed in condensing the air, minus some friction, leakage, and other incidentals. This form settled down into two classes of machines: 1. Those which were locomotive in their character, as in BOMPAS'S air-driven carriage (English patent, 1828), where air was condensed in tanks and admitted to the alternate ends of a cylinder, which had a reciprocating piston, connected in the usual manner to the crank and drive-shaft. The same device, substantially, was used by Von Rathen in 1848, at Putney, England, where he ran an air-locomotive at the rate of ten or twelve miles an hour. See COMPRESSED-AIR ENGINE. 2. Those in which a body of air is condensed into a reservoir, placed at the bottom of a shaft, or in a situation where the prime motor cannot be set up. In this case the engine in the mine is run by the air from the reservoir during a lull in the force of the prime motor. This was the subject of a patent in England, to MEDHURST, 1799. He condensed air to one fifteenth of its volume, and stored it for this purpose. The air-reservoirs of FISK (U. S. patent, 1865) have a similar purpose. See AIR-COMPRESSING MACHINE.

Another form of air-engine has consisted of two chambers filled with air or gas, and connecting by pipes with the respective ends of a cylinder in which a piston reciprocates as the bodies of air in the said cylinders are alternately expanded and contracted. STIRLING'S engine (English patent, 1827) was of this character, and is stated by Chambers to have been unsuccessful, owing to mechanical defects and to "the unforeseen accumulation of heat, — not fully extracted by the sieves or small passages in the cool part of the regenerator, of which the external surface was not sufficiently large to throw off the unrecovered heat when the engine was working with highly compressed air." Mr. Stirling was stated, by the same authority, to have been the originator (1816) of the regenerator wherein the heat of the exhausting air is made to heat surfaces which communicate heat to the incoming air for the next charge. The distinctive form of apparatus was no doubt new with Mr. Stirling, but the main idea is much older, as it is found in the English patent of Glazebrook, 1797. Stirling's regenerator is described as "consisting of a chamber or chambers filled with metallic sieves of wire-gauze, or minutely divided metallic passages, through which the air is made to pass *outward* from the cylinder, after having performed its work on the working-piston of the engine, leaving a great part of its heat in the sieves or narrow passages, to be given out by them again to the returning air, which is made to pass *inward* through the same sieves or narrow passages, and by a slight accession of new heat from the furnace, to produce another effective stroke of the piston. By repeating this process at each stroke of the engine, it is evident that a large portion of the heat that would otherwise go to waste will be used many times over, and thus a smaller amount of new heat will require to be supplied from the heating furnace of the engine, and a corresponding saving of fuel be effected."

Such is the description, but the statement is open to objections.

A further improvement of Messrs. Stirling was patented in England, in 1840.

In this engine two strong air-tight vessels are connected with the opposite ends of a cylinder, in which a piston works in the usual manner. About four fifths of the interior space in these vessels is occupied by two similar air-vessels, or plungers, suspended to the opposite extremities of a beam, and capable of being alternately moved up and down to the extent of the remaining fifth. By the motion of these interior vessels the air to be operated upon is moved from one end of the exterior vessel to the other; and as one end is kept at a high temperature, and the other as cold as possible, when the air is brought to the hot end it becomes heated, and has its pressure increased, whereas its heat and pressure are diminished when it is forced to the cold end. Now, as the interior vessels necessarily move in opposite directions, it follows that the pressure of the enclosed air in the one vessel is increased, while that of the other is diminished; a difference of pressure is produced on opposite sides of the piston, which is made to move from one end of the cylinder to the other. The piston is connected with a fly-wheel, and motion communicated in the usual way.

In this engine the air received heat at the temperature of 650° Fah., and discharged the lost heat at that of 150° Fah. The efficiency of a theoretically perfect engine with those limits of temperature would be 0.45, and its consumption of coal 0.73 of a lb. per horse-power per hour. The actual consumption of coal per horse-power per hour was about 2.2 lbs., being three times the consumption of a theoretically perfect engine, and corresponding to an actual efficiency of 0.15, or one third of the maximum theoretical efficiency. Stirling's air-engine was therefore more economical than any existing double-action steam-engine. The following is a comparison of the consumption of bituminous coal of specified quality per horse-power per hour: —

	lbs.
1. For a theoretically perfect engine, working between such limits of temperature as is usual in a steam-engine . . .	1.86
2. For a double-acting steam-engine, impelled to the utmost probable extent . .	2.50
3. For a well-constructed and properly worked ordinary steam-engine, on an average	4.00

One engine constructed in this manner had a cylinder 12 inches in diameter, 2 feet stroke, and is stated to have worked to 20 horse-power; another engine with a cylinder 16 inches in diameter, 4 feet stroke, worked up to 40 horse-power. The latter, we are informed, did all the work of the Dundee Foundry Company for three years; using only one fourth the amount of fuel previously consumed by its predecessor, the steam-engine. It was then laid aside, owing to some difficulty in renewing the heater. Perhaps it incurred a heavy expense in wear, tear, and the burning out of parts.

The construction of the engine seems to have been essentially a duplication of the invention of PARKINSON AND CROSLEY, English patent, 1827.

In this engine the air-chamber is partly exposed, by submergence in cold water, to external cold, and its upper portion is heated by steam. An internal vessel moves up and down in this chamber, and in so doing displaces the air, alternately exposing it to the hot and cold influences of the cold water and the hot steam, changing its temperature and expansive condition. The fluctuations cause the reciprocation of a piston in a cylinder to whose ends the air-chamber is alternately connected.

While treating of that form of air-engine which depends upon the variation in the thermometric condition of a body or bodies of air, which connect with the opposite sides of the piston alternately, it may be well to mention the engine of BRUNEL, in which carbonic acid gas is stored in two chambers, communicating with the respective ends of the cylinder and operating the piston therein by their thermometric fluctuations. See GAS-ENGINE.

A third form of the apparatus embraces but few features, but these have been modified according to the convictions of independent inventors to such an extent that they are represented by eighty patents now before the writer.

These features may be described as found in GLAZEBROOK'S English patent, 1797 ; a condensed statement of which is as follows : 1. A force-pump to compress the cool air ; 2. a chamber in which the fluid is saturated with moisture (this is not retained by all the modern forms, but is by some) ; 3. A heater where its expansive force is increased ; 4. A cylinder in which its expansive force is utilized against a piston ; 5. A mode of utilizing the heat of the outgoing air, to heat the new charge of compressed cool air for another stroke. Of this latter feature, more hereafter.

In Glazebrook's, the piston of the working-cylinder and that of the pump-cylinder connect with the opposite ends of the working-beam. This inventor's statements of the principles of the operation of his machine are worthy of being quoted at length, but must be condensed for our purpose and limits. His engine was of the differential order, and he states the measure of power to be the difference of force exerted in the working and air-compressing cylinders, of which the latter is much the smaller, and the extra force in the former is due to the accession of heat derived from the furnace wherein the air is heated after compression in the smaller cylinder, and before it is admitted to and allowed to expand against the piston in the larger cylinder. Viewing the history of the air-engine for the seventy years succeeding Glazebrook, we may at least say that he is a great anticipator.

Glazebrook's second patent, 1801, has a refrigeratory, whose use is not, as in RANDOLPH'S (Scotland, 1836), to cool the pump wherein the air is condensed (see COMPRESSED-AIR ENGINE), but is used for depriving the escaping gas of its heat, in case a gas be used of so expensive a character as to preclude its being ejected into the atmosphere after using. This is probably the commencement of using the same air over and over again. He cites carbonic acid and other gases and compounds. He only antedated by three years the engine of Brunel, which was intended to be used without any escape of carbonic acid ; two volumes of which were made to fluctuate in temperature alternately, and produce a pulsation in the chamber placed between them, and in which the piston worked.

LILLEY'S air-engine, English patent, 1819, may be simply noticed as in the same line of invention. The air is compressed by mechanical force ; passed through heated tubes, expanded against a piston, and then escapes into the open air.

The first working-cylinders of the ERICSSON were 168 inches in diameter, and the piston had a stroke of 8 feet, the air being introduced at natural pressure into the heater. The inadequacy of the power developed, and difficulties incident to the scale of the machinery induced him to make it more compact by condensing the air mechanically, and reducing the size of the working-cylinders to 72 inches diameter, and 6 feet stroke. This condensation he did not claim as his own invention, as we understand ; but it is claimed for Stirling at the date of his second patent, 1827. This, however, is not correct, for it is found in the specification of Lilley, English patent, 1819, and in Glazebrook's, 1797. This patent of Glazebrook, in connection with his improvement of 1801, may be considered the most remarkable one of the series, and has just been mentioned. The action of Ericsson gave a great impetus to the invention and building of air-engines ; examples will be cited presently. Air-engines on a small scale are extensively used in driving printing-presses and such like work. It is believed that they are especially suitable for positions where water is scarce, and suggestions have been made for their use in prairie farming, without anything definite being reached in that direction.

The claims put forward for the Ericsson engine indicate that he expected to use the same portion of heat in producing mechanical power over and over again. One who advocated the cause stated that "the basis of the caloric engine is that of returning the heat at each stroke of the piston, and using it over and over again." "This result," he remarks, "Captain Ericsson has attained by means of an apparatus which he styles a regenerator, and so perfectly does it operate that the heat employed in first setting the engine in motion continues to sustain it in full working-force, with no other renewal or addition than may be requisite to supply the inconsiderable loss by radiation."

This would be the legitimate conclusion of the premises stated, and the *reductio ad absurdum*, one would have thought, would have opened the eyes of the claimant. If the statement were true, the engine would become hotter and hotter, unless the fire was almost put out when the engine commenced running, and the power would be used over again to an extent which would put to the blush the mechanical equivalent of a unit of heat in a theoretically perfect engine ; a consummation unexpected, to say the least.

The effect of the claim is, that the heat of the outgoing air is perfectly withdrawn by the regenerator and transferred to the charge of incoming air on its way to the engine, and this without the expenditure of power. The fallacy of the statement, for which Mr. Ericsson may not be responsible, is in supposing that the air could be passed into and through the regenerator in the manner proposed, without the exertion of power. The air, as it enters the regenerator, would expand with the increment of heat acquired therein, and a given volume would require the expenditure of a force to drive or draw it through equal to that which the heat thus absorbed, and expansive condition acquired, would be capable of exerting.

If no power were exerted to induct the air, under these circumstances of expansion, only a part of the charge required would pass into the chamber, and that which reached the furnace would be already attenuated by expansion. Expansion presup-

poses the expenditure of power, and is produced by heat in this case ; the relation of heat to power, and conversely, must not be ignored. The interposition of the air-pump does not affect the problem, for the attenuation of the air by heat will necessitate a greater power to condense a body of air, of given normal volume, into the space where its expansive powers are to be exerted.

The regenerator was used by Stirling, 1816, and Glazebrook, 1797, in air-engines. The forms of the regenerators, however, differ considerably. Stirling's is described in this article, and Glazebrook's appears to have been like a modern air-heater in which the hot current heated pipes filled with the incoming air.

Mr. Ewbank, speaking of the Ericsson regenerator, says : "The principle on which this invention rests is the repeated use of the same caloric. In this engine, as in the steam-engine, heat is the animating principle ; and in using over and over again the same heat, he virtually uses over and over again the same power. He claims to have succeeded in saving upwards of 90 per cent of the heat expended in raising a loaded piston, and in retaining and compelling it to do the same work over again." PAINE in his United States patent, November 30, 1858, moistens and refrigerates the incoming air so as to reduce its bulk, for the sake of getting a partially condensed volume for the supply of the air-pump.

A writer in the English Encyclopædia states the Ericsson experiments as follows : —

"In the summer of 1852 two of Ericsson's caloric engines were at work in a factory at New York ; and as newspaper paragraphs frequently appeared, presenting most favorable accounts of the working of these engines, arrangements were planned for building a ship of 1000 tons' burden, to be propelled by hot air instead of steam. It was anticipated that the Atlantic might be crossed by such a ship in fifteen days, at a vastly cheaper rate than by the superb but costly Cunard steamers, thereby more than compensating for the quicker passage of the latter. The ship was 250 feet long, and had paddle-wheels 32 feet in diameter. On its first trial-trip, January 4, 1853, the ship made twelve knots an hour with the wind, and answered her helm well ; she only used six tons of fuel per day, and was pronounced a success by her friends.

"On the second trial, the maximum speed attained was nine knots, — obtained, as asserted, at a cost only one sixth of that of steam. After this, unfavorable circumstances, one by one, came to light ; and the ship named the 'Ericsson,' in honor of the inventor, failed to establish the validity of the principle involved. Influenced by the results of further experiments made in 1854, the indefatigable inventor took out another patent in 1855 for certain novelties in the apparatus. In this new caloric engine, the heated air, after performing its duty by raising the piston in the working-cylinder, is made to circulate through a vessel containing a series of tubes ; and the current of heated air, in passsing through this vessel or regenerator, is met by a current of cold air, circulating in an opposite direction through the series of tubes on its way to the working-cylinder.

"Thus there is cold air within the tubes and hot air without, an interchange takes place, or rather an equalization, by a transference of caloric from one to the other.

"The current of cold air, on its way to the working-cylinder, after thus having been partially heated by the transference of caloric, is made to pass through a series of tubes or vessels exposed to the fire of a furnace.

"The action of the engine itself is what is called 'differential,' the motive energy depending on the difference of areas in the working and supply cylinders. [And the superior energy of the charge in the former due to its increment of heat derived from the furnace. — ED.]

"The heater and regenerator are supplied with fresh compressed atmospheric air at each stroke of the engine.

"In the year now under notice [1855], the old caloric engine was taken out of the 'Ericsson,' and steam-engines substituted. Captain Ericsson would not admit, however, that this was an evidence of failure in his plans ; he still asserted the soundness of the principle, and the economy in fuel.

"The first engine made was, he said, too cumbrous for the available amount of power in the ship, and the losses by leakage and friction were greater than had been anticipated. A second was made ; but the joints of the pipes of the heaters were not good, and could not bear a greater pressure than such as would produce a speed of seven knots an hour. Surcharged or overheated steam was used, because the hot air escaped, and then occurred a dislocation of the whole machinery by an explosion.

"This action led to the substitution of steam-boilers ; but even then Ericsson would not admit that the *principle* of his caloric engine was proved to be unsound ; seeing that the accident had arisen from mechanical defects, and that the change consisted only in the use of steam-boilers instead of air-heaters." The English writer is here incorrect, as she was supplied with steam-boilers *and* engines.

The "Ericsson" made a trip from New York to Washington, and is said to have used an enormous quantity of tallow in lubricating her machinery. This difficulty is avoided in some of the smaller machines now built, by saturating the air with steam. See AËRO-STEAM ENGINE.

In a paper read by Mr. Rankine before the British Association in Liverpool, September, 1854, is a succinct statement of the principles underlying this subject of invention ; from it we derive the following : —

"Heat acts as a source of mechanical power by expanding bodies, and conversely, when mechanical power is expended in compressing bodies, or in producing friction, heat is evolved. This mutual convertibility of heat and mechanical power is expressed in the following law : 'That when mechanical power is produced by the expenditure of heat, a quantity of heat disappears, bearing a fixed proportion to the power produced ; and conversely, that when heat is produced by the expenditure of mechanical power, the quantity of heat produced bears a fixed proportion to the power expended. This law has been established chiefly by the experiments of Mr. Joule on the production of heat by the friction of the particles of various substances, solid, liquid, and gaseous, and he has ascertained the fixed proportion which heat and mechanical power bear to each other in cases of mutual conversion.

"The *unit of heat* — or so much heat as is sufficient to raise the temperature of one pound of water at ordinary temperatures by one degree of Fahrenheit's thermometer — requires for its production, and produces by its disappearance, or, in other words, is equivalent to, 772 lbs. of mechanical power ; that is, so much mechanical power as is sufficient to lift a weight of 1 lb. to a height of 772 feet. This quantity is known as *Joule's equivalent*, or the dynamical specific heat of water at ordinary temperatures. The dynamical specific heats of other substances may be determined by direct experiment, or by ascertaining the ratios to that of

water. Thus, to heat 1 lb. of atmospheric air, maintained at a constant volume, by 1° Fahrenheit, requires the expenditure of 130.5 foot lbs. of mechanical power. This is the *real* dynamical specific heat of air. The *apparent* dynamical specific heat of 1 lb. of air, under constant pressure, is, for 1° Fah., 183.7 foot lbs.; the difference, or 53.2 foot lbs., being the mechanical power exerted by the air in expanding, so as to preserve the same pressure notwithstanding the increase of its temperature by 1°. The apparent specific heat of air at constant pressure exceeds the real specific heat in the ratio of 1.41 : 1. All quantities of heat may thus be expressed by equivalent quantities of mechanical power. The heat required to raise 1 lb. of water from the freezing to the boiling point, and to evaporate it at the latter temperature, is $1{,}147.5° \times 772 = 885{,}870$ foot lbs.: of which $180° \times 772 = 138{,}960$ foot lbs. is sensible heat, or that employed in raising the temperature of the water; while the remainder, $967.5° \times 772 = 746{,}910$ foot lbs., is the latent heat of evaporation of 1 lb. water at 212° Fah., or the heat that disappears in overcoming the mutual attraction of the particles of water, and the external pressure under which it evaporates. The mechanical equivalent of the available heat produced by 1 lb. of ordinary steam coal may be taken on an average of that of the heat required to raise 7 lbs. of water from 50° to 212° Fah., and to evaporate it at the latter temperature, that is to say, in round numbers, 6,000,000 foot lbs. The total heat is much greater, but there is a loss in the gases which ascend the chimney.

"Heat, being convertible with mechanical power, is convertible also with the *vis viva* of a body in motion. The British unit of heat, 1° Fah. in 1 lb. of water, is equivalent to the *vis viva* of a mass weighing 1 lb. moving with a velocity of 223 feet per second, being the velocity acquired in falling through a height of 772 feet. A mass of water, of which each particle is in motion with this velocity, has its temperature elevated by 1° of Fah. upon the extinction of the motion, by the mutual friction of the particles. Heat communicated to a substance produces in general three kinds of effects (omitting the chemical and electrical phenomena): 1. An increase of temperature and expansive pressure. 2. A change of volume, nearly always an increase. 3. A molecular change, as from the solid to the liquid, or from the liquid or solid to the gaseous state. The heat which produces the first kind of effects is known as *sensible* heat, and makes the body hotter. In the second and third kinds of effects heat disappears and becomes *latent;* but may be reproduced by reversing the change which caused it to disappear. In evaporating 1 lb. of water at 212° a quantity of heat disappears equivalent to 746,910 foot lbs. The pressure of the steam produced is 2,116.4 lbs. on the square foot. The volume is probably about 26½ cubic feet more than that of the liquid water. Multiplying these two quantities together, it appears that the heat expended in overcoming external pressure is equivalent to only 56,085 foot lbs., leaving 690,825 foot lbs. for the mechanical equivalent of the heat which disappears in overcoming the mutual attraction of the particles of the water. Whereas the latent heat of expansion of a permanent gas consists almost entirely of heat which disappears in overcoming the external pressure. Thus the product of the volume in cubic feet of 1 lb. of air, at 650° Fah., by its pressure in lbs. per square foot, is 59,074 foot lbs. If that 1 lb. of air be expanded under pressure to 1½ times its original volume, and still be maintained at the constant temperature of 650° by being supplied with heat from an external source, the work performed by it in expanding will be $59{,}074 \times$ hyperbolic logarithm of $1\frac{1}{2} = 23{,}953$ foot lbs., and this quantity will also be sensibly equal to the mechanical equivalent to the heat supplied, and which disappears during the expansion. It is this heat which disappears in producing increase of volume under pressure, which is the real source of power in the performance of a thermo-dynamic engine; as it is a portion of this heat which is actually converted into mechanical work, while the heat expended in producing elevation of temperature produces merely a tendency to the development of power. When an elastic substance has to perform mechanical work through the agency of heat, it goes through a cycle of four processes, which, taken together, constitute a single stroke of the engine.

"*Process A.* — The substance is raised to an elevated temperature. This process may or may not involve an alteration of volume.

"*Process B.* — The substance, being maintained at the elevated temperature, increases in volume and propels a piston. During this process heat disappears, but an equivalent quantity is supplied from without, so that the temperature does not fall.

"*Process C.* — The substance is cooled down to its original low temperature, with or without a change of volume.

"*Process D.* — The substance, being maintained at its depressed temperature, is compressed, by the return of the piston, to its original volume. During this process heat is produced; and in order that it may not elevate the temperature of the substance, and give rise to an increased pressure, impeding the return of the piston, it must be abstracted as quickly as produced, by some external means of refrigeration. The substance, being now brought back to its original volume and temperature, is ready to undergo the cycle of processes again; or it may be rejected, and a fresh portion of the substance employed for the next stroke. In the latter case the operation of expelling the substance may take the place of process *D*. In some cases the processes *B*, *C*, or *D* may be first in the order of time. During the cycle of processes the working substance alternately increases and diminishes in volume in contact with a moving piston. During the increase of volume the pressure of the substance against the piston expends mechanical power in compressing the working substance. The increase of volume takes place at a higher temperature, and therefore at a higher pressure than the diminution of volume; consequently, the mechanical power communicated to the piston exceeds that taken away from it. The surplus is the power of the engine, available for performing mechanical work. The efficiency of the thermo-dynamic engine is the ratio which the available power bears to the mechanical equivalent of the whole heat expended. If the heat communicated to the working substance entirely disappeared, the power produced by that engine would be the exact equivalent of the heat expended, or 772 foot lbs for each unit of heat, and its efficiency would be represented by unity. A perfect engine would produce power to the amount of 6,000,000 foot lbs., for each pound of coal consumed; and as a horse-power is 1,980,000 foot lbs. per hour, the consumption of coal would be 0.33 lb. per horse-power per hour. But of course there is a waste of heat and power to be allowed for in every engine before we can arrive at its actual efficiency."

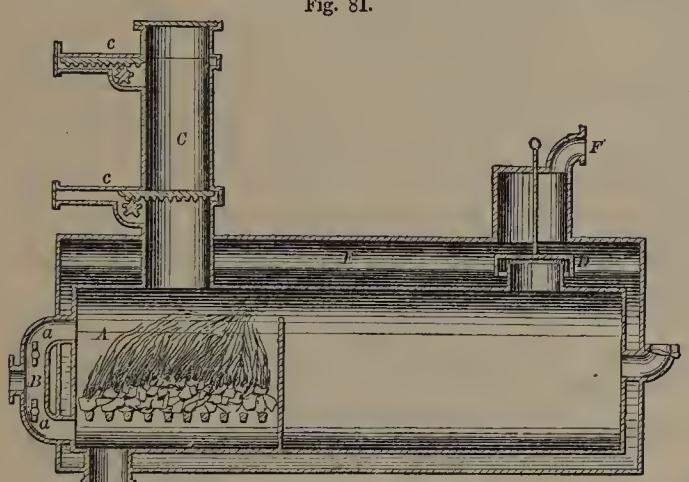
The efficiency of a theoretically perfect engine, working between the same temperatures as Ericsson's,

would be 0.404, corresponding to a consumption of 0.82 lb. of coal per horse-power per hour. The actual consumption was 1.87 lbs. of anthracite, or 2.8 lbs. of bituminous coal. This is about 3.4 times the consumption of a theoretically perfect engine, and corresponds to an actual efficiency of 0.118, being less than the maximum theoretical efficiency in the ratio 0.295 to 1. The waste of heat and power, therefore, in Ericsson's engine must have been very great, though it was economical of fuel as compared with steam-engines.

Many of the modern forms of air-engines conduct the incoming charge of air to the furnace and make it the means of maintaining combustion. The volatile results, abounding in carbon and deprived more or less perfectly of the oxygen, require washing to remove the dust and soot which would otherwise pass to the cylinder. Combustion is thus maintained under pressure, a condition considered by many to be very favorable to the economical use of the fuel.

Some of the air-engines of late construction use a larger or smaller proportion of steam, partly as a motor and partly as a lubricator of the parts which are apt to grind, working in the hot, dry air. See AËRO-STEAM ENGINE.

Fig. 81.

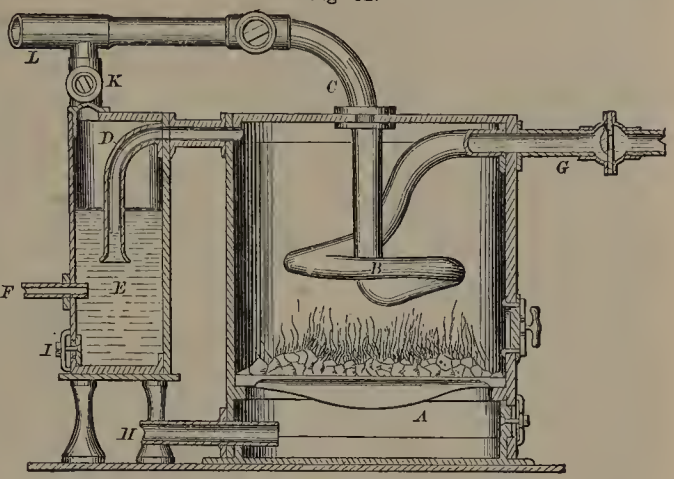


Bennett's Air-Heater and Steam-Generator.

BENNETT, August 3, 1838. This is a combined air-heater and steam-generator, the combustion being maintained under pressure. The air is forced in by a pump, and enters above and below the grates in quantities regulated by the dampers *a*, *a*, in the branches of the pipe *B*. Coal is introduced through the charger *C* above, without allowing any notable amount of air to escape. The upper valve *c* being withdrawn, a charge of coal is dropped on to the lower valve, when the upper valve is shut, and the withdrawal of the lower one allows the coal to fall into the furnace *A*. The volatile products of combustion pass through the water-trap *D*, and mingle with the steam generated in the jacket *E*. The caloric current is purged of its grit and soot by the water in the trap *D*, and the combined heated air, gases, and steam pass by the pipe *F* to the engine. An equal pressure is maintained in the furnace and in the steam-generating chamber.

WASHBURN, September 5, 1865. The water passes by pipe *G* to the coil *B*, where it is converted into steam which passes off by pipe *C*. Air from a force-pump enters the ash-pit *A* by the pipe *H*, and after supporting combustion in the furnace, the volatile portions pass off by the pipe *D* to the wash-box *E*,

Fig. 82.

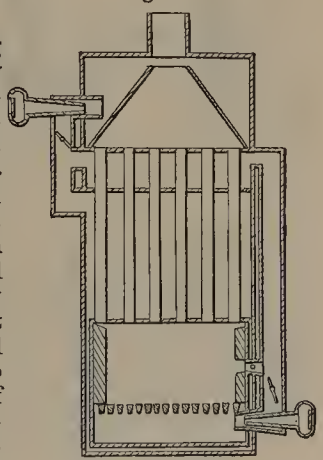


Washburn's Air-Heater and Steam-Generator.

where the grit and soot are arrested. *F* is a water-supply pipe and *I* a hand-hole for withdrawing accumulated matter arrested in the bath. After being deprived of impurities, the air passes by the pipe *K*, and joins the steam, the two passing by pipe *L* to the engine. The pressure throughout the apparatus is equal, the air and water being forced into it at a pressure equal to that of the outgoing steam and air. The steam-generating tube *B*, being exposed to equal pressure within and without, may be of light material, and the hot-air current may vaporize a portion of the water in the cleanser *E*, which is also supplied under pressure. The strength is in the outer walls.

STILLMAN, August 9, 1864. The air-heating chamber is surrounded by a steam-generator, the steam from which is made the means, by injectors, of introducing the supply of air below the grate of the furnace, and also at a higher point, where it acts to assist the draft. For this purpose the steam in the generator is maintained at a higher temperature than the air in the furnace, and acts as a substitute for the air-pump in affording a supply of air for combustion of the fuel under pressure.

Fig. 83.



Stillman's Hot-Air and Steam-Generator.

After the foregoing treatise on the early history of the air-engine and the consideration of the principles involved, the remainder of this article will be devoted to examples of the air-engines which have been introduced during the last twenty years. They are about eighty in number, and may be divided into five classes, in all of which the air is expanded by heat. (Air-engines into whose action heat does not enter

as an effective agent are considered under COMPRESSED-AIR ENGINE, which see.)

1st. Those in which the air is compressed into a reservoir, emitted in graduated amounts, heated, used effectively against a piston in a cylinder, and then discharged. This is the most numerous class. Some of them pass their air-supply through the furnace, and in others it is only heated by the furnace. In the former the discharge of the air is a necessity, not so in the latter; this brings us to the

2d. Those in which the air or gas is not expended, but the same air is caused to return to the heater and be again expanded and utilized. This is the subject of the English patent of Glazebrook, 1801, and Laubereau, 1859; and the United States patent of the latter dated 1849.

3d. Those engines in which the air or gas is not expended, but occupies two reservoirs communicating with the cylinder on the respective sides of the piston; the air in said reservoir being alternately heated and cooled to change its expansive force and thus reciprocate the piston. This was the form of Brunel's engine, British, 1804; and Stirling's, British, 1827; and Peters's, 1862.

4th. Those engines in which water or steam is mingled with the air to moisten it and keep the working parts from abrasion; in some cases being introduced in quantity to be positively co-operative. These are AËRO-STEAM ENGINES, which see.

5th. Those engines in which the power derived is transferred to a body of water, to prevent burning the working parts and to obviate the necessity for air-tight joints.

It will be apparent that only a few representative examples can be shown within the limits assignable to this subject, in which, as is commonly the case, some inventors have numerous patents embracing details of construction, as the working of their engines developed defects and elicited remedies.

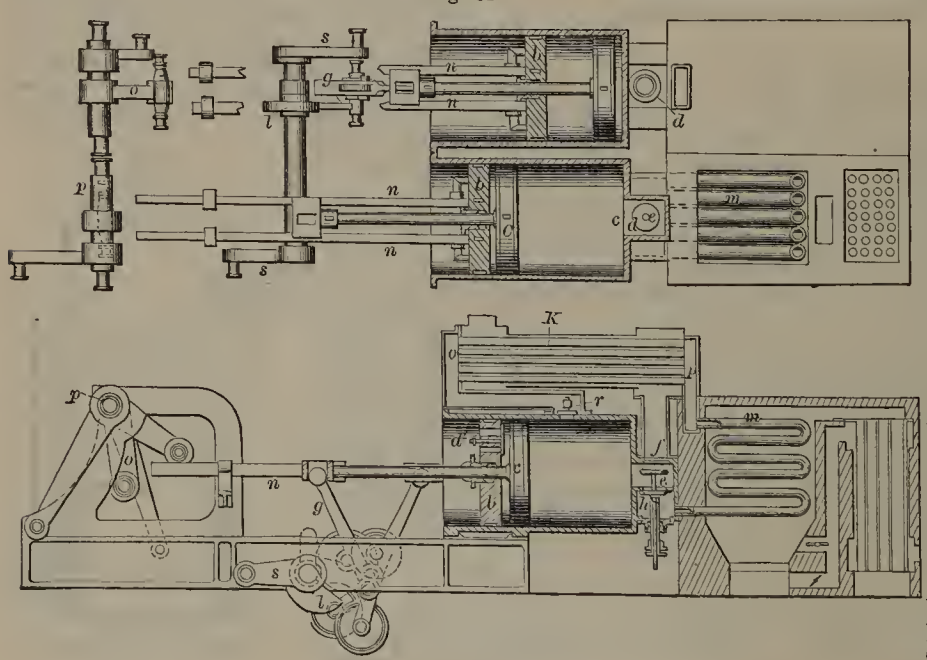
The first class is after the similitude of the Glazebrook, 1797, and Lilley, 1819.

Ericsson patented improvements in air-engines in 1851, 1855, 1856, 1858, and 1860. The following affords an example of one of his engines.

ERICSSON, specification patent of July 31, 1855, describes the invention substantially as follows (the illustration is reduced, from the official drawing, for this work): —

b is the working-piston; *c*, the supply-piston; *f*, the exhaust-port; *c*, the induction-port. The regenerator consists of tubes *k*; *m* are the heater-tubes. By means of a hand air-pump, applied to some part of the regenerator, a supply of atmospheric air is introduced at about the pressure of the atmosphere, and then the engine is in a condition to begin its operation. Starting with the pistons of one engine in the position represented in the lower view, Fig. 84, at the extremity of their outward stroke, as the crank *s*, moving in an upward direction is making that part of its circuit near the outer dead-point, and therefore imparting but little motion to the working-piston *b*, the supply-piston *c* is carried from the working-piston and towards the head of the cylinder with a rapid motion by the action of the cam on the roller of the arm *g*, the cam rotating in the direction aforesaid, and its acting face being formed as represented, that the piston may be gradually started, rapidly accelerated, and, near the end, gradually arrested, and there retained in a state of rest as the extremity of the cam passes the roller. During this inward motion of the supply-piston, the working-piston will be opened by the pressure of the atmosphere, to permit cold air to enter and fill that part of the cylinder between the two pistons. So soon as the supply-piston stops, the exhaust-port closes, and the continued inward motion of the working-piston begins to compress the cold air thus supplied, which of course closes the self-acting valve *d*, through which the supply was admitted by atmospheric pressure. Thus supplied, cold air continues to be compressed by the working-piston, until the end of its inward stroke; and, as the power for effecting this compression is derived for the time being from the other engine, it is important to observe the condition of the connections. At the time the supply-piston of one engine is started, and the air is entering by atmospheric pressure, and when the arm *o*, on rock-shaft *p*, with which the working-piston is connected by the rod *n*, is at its greatest leverage, the corresponding arm of the rock-shaft of the opposite engine is at its shortest leverage, but is moved inwards, and the supply-air, by reason of being gradually compressed, increases the resistance, the arm *o* gradually shortens in leverage, and the same arm of the opposite engine gradually, and in nearly the same ratio, increases in leverage, on the principle of the bent lever; thus applying the power required to compress the supply-air to the best advantage. It should be borne in mind, however, that the power thus applied to compress the supply-air is not actually expended, but merely borrowed; for it is so

Fig. 84.



Ericsson's Air-Engine (1855).

much added to the elastic force of the air by which, when heated, the engine is impelled.

Just before the supply-piston begins the inward stroke, just described, the eduction-valve *g* is opened, the induction-valve *h* having been previously closed so that the charge of the heated air, by which the previous stroke of the engine was effected, is permitted to escape freely into the atmosphere, so that the power required to move the supply-piston inward is very slight, the air escaping freely to the atmosphere on one side, and entering by atmospheric pressure on the other, through the valve *d*; but as the heated air exhausts or escapes from the cylinder, it passes around and among the series of small tubes *k*, of the regenerator, thus imparting its heat through the metal of the tubes to the cold air contained inside of the tubes, which air is thus partially heated preparatory to being finally heated in passing through the heater-tubes. In this way much of the heat which would be otherwise wasted is saved. The supply of cold air having been introduced and compressed, the engine is prepared to be impelled by the expansive force of the heated air. The eduction-valve *g*, having been closed during the greater part of the inward motion of the working-piston, the induction-valve *h* is now opened, which admits the heated air from the heater of the cylinder by which the supply-piston is forced outwards towards the working-piston. The form of the fall of the cam *l* is such as to cause the piston to be carried back with a rapid accelerated motion, until it comes nearly in contact with the working-piston; and, at first, in this outward motion of the supply-piston, the already compressed supply-air between the two pistons is still further compressed, not by the power of the engine, but by the elastic force of the heated air, the supply-piston being as it were suspended between the heated air from the heater on one side and the cold air of the other, with the self-acting valve *r* (in the side of the cylinder) interposed between the two; for it must be remembered that, as the heater and regenerator are in communication, the air, which is a perfectly elastic fluid, will be under equal pressure in both, notwithstanding a portion is more highly heated than the other; and, as the supply-air in the cylinder is simply separated from the air in the regenerator by the interposed valve *r*, in the side of the cylinder, the supply-piston will be moved outwards by the heated air, until the supply-air is compressed to an equal tension, and then the further motion of the supply-piston, effected by the cam *l*, as it approaches the working-piston, will transfer the supply-air from the cylinder to the regenerator, through valve *r*. The only power expended by the engine in this transfer will be the small amount required to move the supply-piston, between two equal pressures, to give the slight preponderance to the one necessary to open the valve *r*, through which the transfer is made. The moment the supply-piston passes this valve and overtakes the working-piston, the preponderance of pressure ceases, and the valve closes by gravity.

The specification states: "I *claim* the method of supplying fresh air to the engine, compressing and transferring it to the regenerator and heater, or either, by the action of the supply and working pistons within the one cylinder, operating on the principle and in the manner substantially as described, whereby the air is admitted, under atmospheric pressure, as the supply-piston is moving from the working-piston, as the previous charge of heated air is exhausting; so that the said supply-piston moves in equilibrio, or nearly so, and by which also the supply-air is finally compressed and then transferred to the regenerator and heater, or either, as the supply-piston moves between the supply-air and heated air, during the periods of the nearly stationary position of the working-piston.

"I also claim, in combination with the double-piston movement of each cylinder, the methods of connecting the working-pistons of two single-acting engines to constitute a double-acting engine, by means of two sets of vibratory arms attached to each other, and vibrating on a common center connected with the two working-pistons, and with the two cranks on opposite sides of the crank-shaft, the two sets of arms acting on the principle of the bent-lever, and the crank-shaft being so located relatively to the cylinders and the centers of vibration of the arms, substantially as described, that the working-piston shall be at the end of its inward stroke at the time the crank is passing the dead point farthest from the point of connection of the connecting-rods with the vibrating-arm, as described, by which the power of that working-piston which is being impelled by the heated air is applied to the best advantage to operate the other working-piston during its return-stroke, and by which also the working-piston remains nearly at rest during the time the supply-piston is making that part of its outward stroke, during which the partially compressed air is finally and fully compressed and transferred to the regenerator and heater, or either, as described."

Since the experiments on a large scale, a smaller size of the Ericsson engine has been made efficient.

An Englishman, who was deputed to examine the engine, made a published report in which the following is found: —

"They all gave complete satisfaction and apparently ample power for the purposes to which they were applied; but without experiment it is impossible to say what quantity of power they actually furnish respectively, but, judging by the appearance of things, they all worked well and with surprising regularity, evidently developing a much larger amount of power from a given quantity of coal than could be obtained from steam-engines, as at present constructed, of corresponding powers. And being such that they may be placed in any location from which a chimney may be reached, and not requiring water or skilled attendance, they are particularly desirable as a driving power for small manufacturers, who are thereby enabled to conduct their operations in the business parts of the cities, by occupying upper lofts.

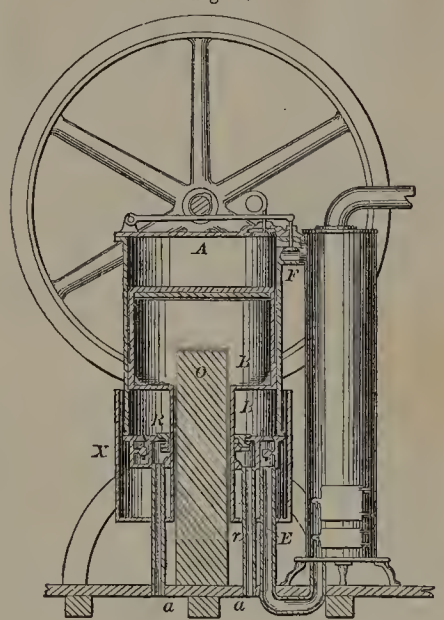
"No attention is required for them while running, beyond what is necessary to throw in a few coals occasionally, which is all that is required to keep up a constant and uniform motion, — which considerations become of importance to those who require a small power only.

"As to the appreciation of this machine by the public, it may well be said that whereas it was a few years ago looked upon as a mere mechanical curiosity, it is now regarded and acknowledged as a reliable motive power."

The "London Engineer" adds: "That it is possible to construct an air-engine which will burn less coal than an average steam-engine has been almost proved, but it is wrong to argue from this that the steam-engine is 'used up.' Something more is wanted than economy of fuel. We need permanence, absence of wear and tear, compactness, simplicity, and safety. In every one of these points, except perhaps the last, hot-air engines cannot bear a moment's comparison with the steam-engine. No large hot-air engines have ever been constructed and

worked with success. The rubbing surfaces must be huge, and an efficient lubrication becomes an impossibility, hence friction is enormous. The dimensions of the working parts must be very great, or the temperature of the air very high. Surfaces nearly red hot cut into each other, and friction runs away with the power of the machine, the destruction of which is imminent each day. Considerable improvements may be effected in lubrication, but experience with the steam-engine conclusively proves that the limit of temperature consistent with practical working is very soon passed. It is not safe to use superheated steam much hotter than 280 degrees, the cast-iron of the cylinders and valve faces becoming disintegrated and spoiled at higher temperatures. If air of no greater temperature is used, we have an effective pressure of not more than 7 lbs., or thereabouts, per square inch. Marine

Fig. 85.

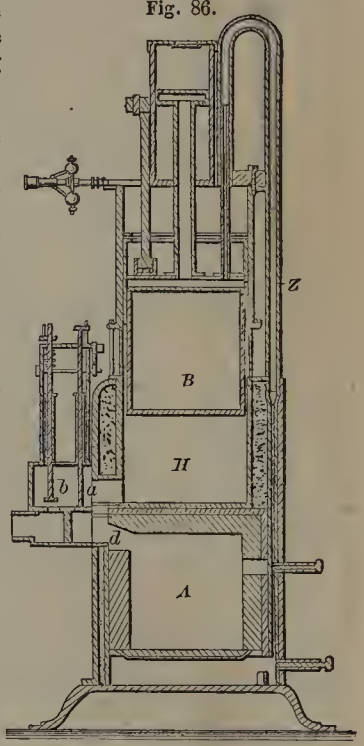


Stillman's Air-Engine.

engines with cylinders of 100 inches in diameter must be replaced under such a condition with others of 15 feet or 16 feet in diameter. Then would come huge air-pumps and regenerators. The machinery would take up as much space as boilers and steam-engines together; and all this to save perhaps a quarter of a pound of coal per horse per hour."

Stillman, June 26, 1860. The air is compressed and worked in a single cylinder by a single piston. The air is compressed in the space below the piston *B*, passes by pipe *E* to the heater, and thence by valve *F* to the effective space *A* above the piston. As the piston rises, air is drawn in between the hollow piston-rod *B'* and the plunger *O*, cooling the former, and is ejected again as the piston descends. The induction-air enters at pipes *a a*, as the piston rises, the annular valve *R* being raised by the friction of its stuffing-box upon the hollow piston-rod *B'*. The cylindrical chamber *X* is attached to the piston-rod *B'*, and rises and falls therewith so as to alternately draw and expel air through the annular space between it and the cylinder, for the purpose of cooling the latter.

Fig. 86.

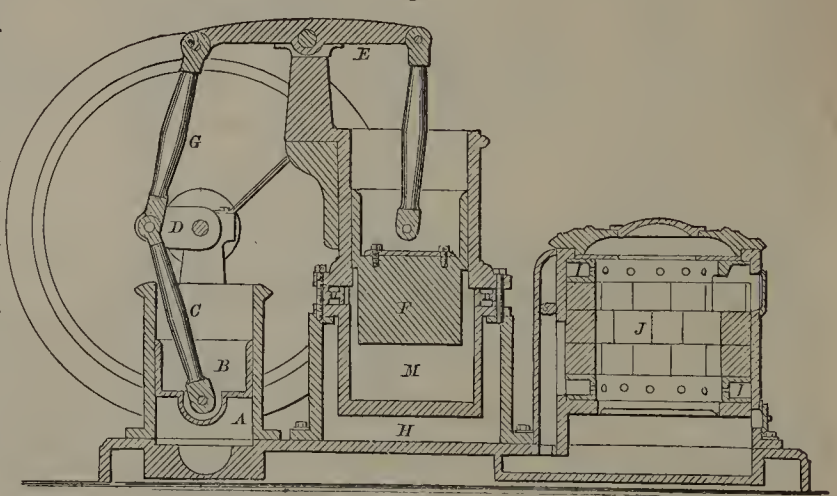


Roper's Air-Engine.

Roper, June 9, 1863. The furnace is lined with fire-brick on all sides except the bottom. The air is condensed in the pump above and passes down by the pipe *Z*, being admitted above or below the grate in quantities proportioned to the requirements of the fuel. The air passes from the furnace *A* by an opening *d*, and is admitted, on the rising of valve *a*, to the space *H*, when it is rendered effective against the piston *B*. The exhaust-valve *b* is raised to allow the descent of the piston, the valves being automatically worked by the usual means, and the cut-off being adjustable as required.

Baldwin, February 14, 1865. In this engine the air is driven out of the force-pump *A* by the descent of the piston *B*, which is connected by pitman *C* with the crank *D*. The air from the pump *A* passes, by passages *H*, to the tuyeres *I* around the furnace *J*; into which it issues by a series of openings on the inner faces of the annular tuyeres. These air-passage rings are interchangeable with the movable rings which form the lining of the furnace. The air passes from the primary to a secondary furnace, and thence by passages and valve-ways to the working-cylinder *M*, where it

Fig. 87.



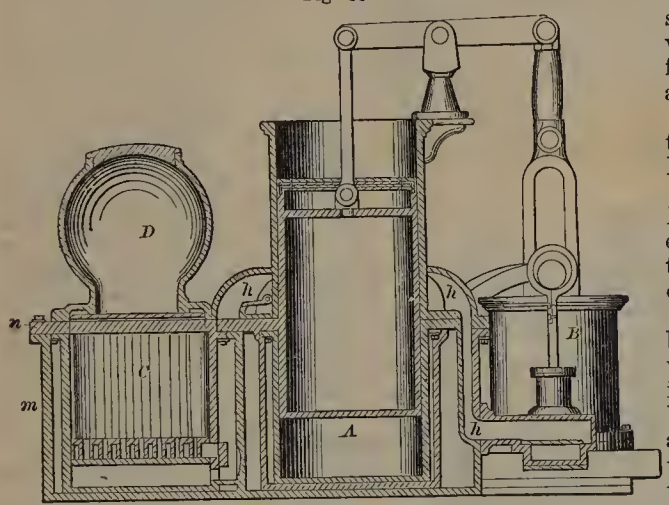
Baldwin's Air-Engine.

acts upon the piston *F* to raise the walking-beam *E*, and the latter connects by pitman *G* with the crank *D*.

The disk-valves are made of flexible material, and are guided by marginal, vertical pins, which form a cage to restrain the disks from lateral movement, but permit free, vertical play. The air, after expanding in the working-cylinder, becomes sensibly colder and is exhausted into the atmosphere. A connecting-rod eccentrically journaled to the main-shaft operates toes which trip the inlet and exhaust-valves of the working-cylinder.

Messer, March 7, 1865. The cylinder *A*, air-pump *B*, and furnace *C* are on a plane, and the feed-box *D* over the latter. The packed portion of the piston works in the upper part of the cylinder, which is cooled by air in the passage *h*, leading from the air-pump to the furnace. A check-valve in the passage prevents the reflux of air. The foundation-plate of the engine has high sides *m*, and forms a water-reservoir in which steam is generated by radiation from the furnace-walls. A top-plate *n* forms the top of the reservoir, and the cylinder is protected by a double wall which prevents immoderate subtraction of heat therefrom. Air from the pump circulates through the hollow grate-bars. A pump is provided for injecting combustible fluid, to

Fig. 88.



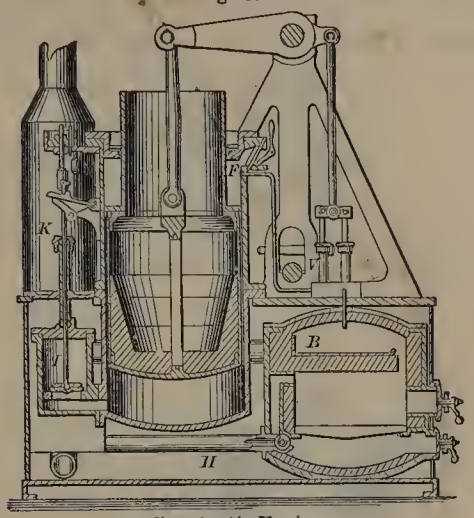
Messer's Air-Engine.

mix with the solid fuel in the furnace, and all the volatile products of combustion are passed through the working-cylinder, the induction and eduction valves being worked in the usual manner.

Wilcox, May 16, 1865. This engine is substantially on the principle of the engine of Sir George Cayleys (about 1830). The fire is fed with air, under pressure of a pump, and the volatile products of combustion are passed through the working-cylinder.

With each descent of the piston air is drawn through the inhaling valve *F*, and fills the space above the piston. On the ascent of the valve the air is driven through the regenerator, and becomes partially heated by contact with the ducts carrying out heated exhaust-air. It thence passes by pipe *H* to the furnace, a part entering above and a part below the grate as regulated by the faucet-valve. This valve is worked automatically by a thermostatic arrangement, so that when the fire becomes unduly heated the supply driven *through* the fuel is decreased and combustion checked. The compressed and heated air thence passes, by pipe *B*, to the

Fig. 89.



Wilcox's Air-Engine.

valve-chest *I*. The raising of the valve admits air to the effective space below the piston, and closes by the tripping of the adjustable cut-off arrangement; this is effected late or early in the stroke, as may be required.

The doors of the furnace and ash-pit are secured by cramps and hollow bolts to the walls, and are removable to replenish the fuel, or for grinding or packing to make an air-tight joint.

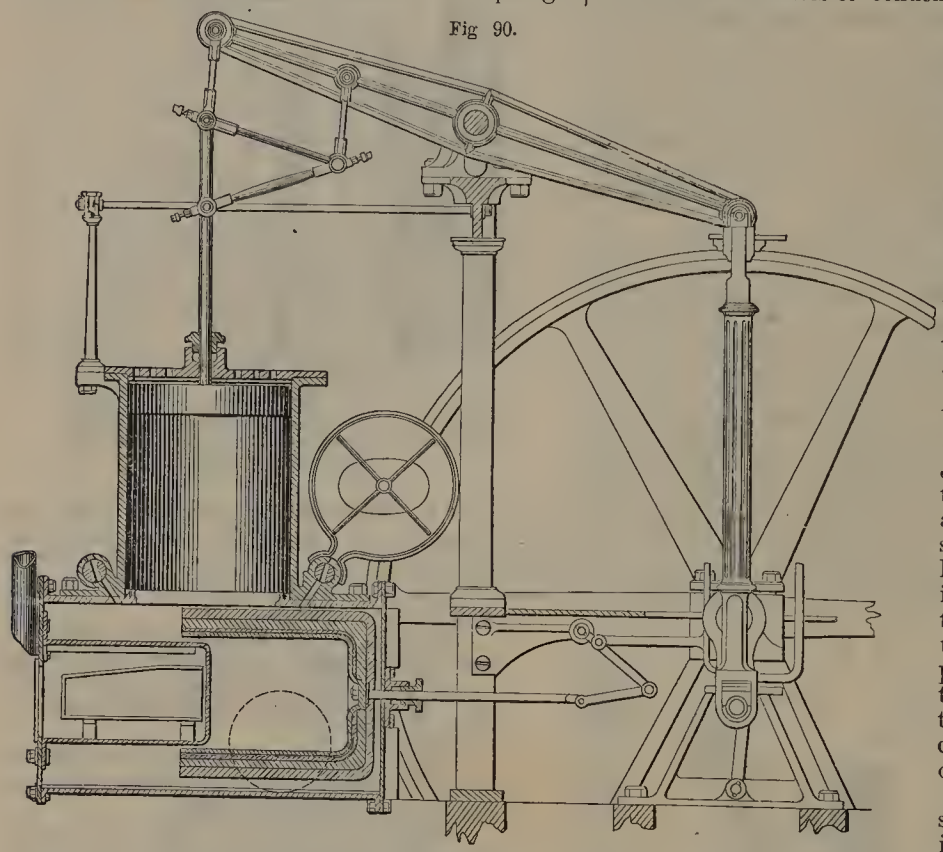
2. The second class is as the principle of the English patents of Glazebrook, 1797; and Parkinson and Crosley, 1827.

Laubereau, April 10, 1849; patented in England, 1847. This engine is the first which embodies the peculiar features of a furnace in the air-heating chamber, and a hollow plunger of corresponding form.

The air is alternately dilated and contracted by absorbing and giving out calorie, the air when separated by heat forcing up a piston in a cylinder, which is in turn forced down by the pressure of the atmosphere when the air is condensed by the abstraction of heat, the air for the alternate dilatation and contraction being carried over a heating and cooling surface by the motion of a plunger in a cylinder that communicates with the cylinder of the engine. The plunger is made hollow, with its external and internal surfaces made of some good conductor of calorie separated by a non-conductor, the said plunger being adapted to move within a surrounding cooling-vessel and so combined with a heating-vessel made of some good conductor of calorie, and heated by the application of heat internally, that the said hollow plunger shall alternately cover and uncover it, and thus cause the contained air alternately to pass over the heated surfaces to dilate it, and then over the cold surfaces to contract it, the said surrounding vessel being in connection with a cylinder to which is adapted a working-piston. The operation is as follows: before heat is applied, air is admitted, under the pressure of the atmosphere, through one of the valves or cocks; fire is then made in the furnace until the contained air is dilated; a portion of which is then permitted to escape through one of the valves or cocks, which is then closed. The heat is then continued until the air has acquired sufficient elasticity to force up the piston. This communicates motion to the crank-shaft, and toward

the end of the upward motion of the piston, the cam on the main shaft moves the plunger until it covers the heater, and this motion of the plunger causes the air contained between it to pass between its outer surface and the inner surface of the surrounding vessel, and to accumulate at the back end of the plunger, so that, the heat being entirely shut in, the air is cooled by contact with the cold surface of the surrounding case and outer surface of the plunger, the air thus contracted producing a partial vacuum which permits the piston to be forced down by the pressure of the atmosphere above. As the piston approaches the end of its downward stroke, the cam moves back the plunger, which transfers the cold air from the outside to the inside, thus causing it to pass in a thin film over the surface of the heater and the inner and heated surface of the plunger. It is thus again dilated, that by its elasticity it may again force up the piston. In this way each stroke of the plunger causes the air to pass over the heated surfaces to dilate it, and then over the cold surfaces to condense it. The plunger also has the effect to shut in the heat of the heater, receiving heat therefrom in the mean time while its external surface is kept cold by the surrounding case, the non-conductor interposed between them preventing the heat of the internal surface from being transmitted to the external surface.

Fig 90.



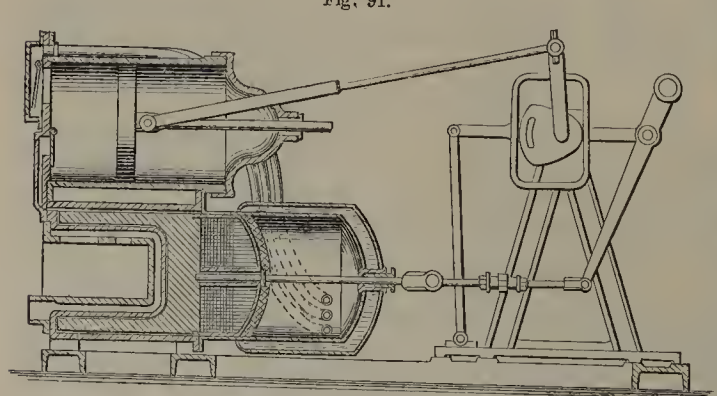
Laubereau's Air-Engine (1847).

This engine has been since modified (patent in England, July 22, 1859) by the introduction of a valve in the passage between the heater and working-cylinder, and at the eduction from thence into the pipes which conduct the air back from the working-cylinder to the cool end of the chamber.

This air-engine is said to be coming into great favor on the continent of Europe, and in the later form is very compact. The operation of the engine is so similar to the preceding that it does not call for a lengthy description. The jacket around the cool end of the air-chamber has a current of water, or some other means of refrigeration, so as to render it more prompt and effective in its action on the air. The working-cylinder is connected alternately to the respective ends of the chamber below, by passages whose valves open and close, according to the direction of the current.

Schwartz, December 20, 1864. This invention is thus described officially: "The object of this invention is to produce an air-engine to work upon the recuperative system, and thus to use the same air over and over. Its novelty consists, first, in the generator, which is composed of a strong flat-sided vessel, with rounded neck at the top, which is suspended over the fire in the furnace. From the bottom of this generator protrude downwards several bottle-shaped tubes which are open towards the inside space of the generator. This generator is filled with a liquid whose boiling-point is very high, say from 500° to 700°. The air heated in the generator passes through a pipe to the cylinder, which constitutes the second novel feature of the engine, and is composed of three distinct parts, the central one of which is the working-cylinder, the end ones being filled with small tubes, into which rods are fastened to the piston-neck for the purpose of agitating the entire body of air during the process of expansion. The third

Fig. 91.



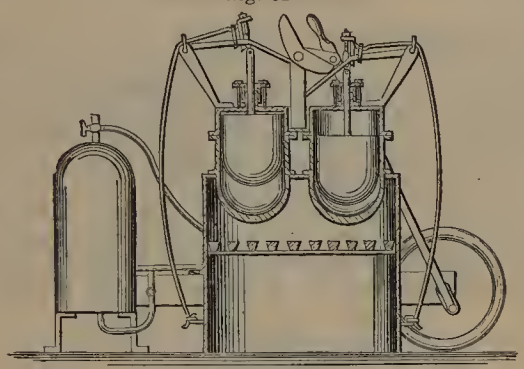
Laubereau's Air-Engine (1859).

feature of novelty consists in passing the gas, after it has expended its force upon the piston, through the generator, which is constructed rectangularly, and has a dividing plate in its center. This vessel is filled with horizontal tubes, which are closed at both ends, and are partially filled with a fluid which is designed to extract the heat from the air or gas as it passes from the engine, and transmits it to the air which is passing to the opposite side of the piston."

3. The third class is on the principle of the Stirling engine, described in a preceding portion of this article.

PETERS, November 18, 1862. The air is heated

Fig. 92



Peters's Air-Engine

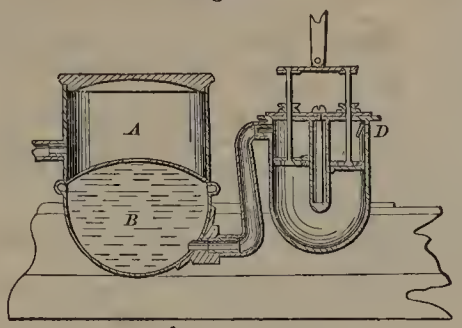
in two vessels connected with two opposite ends of the working-cylinder, and the invention consists in so operating the two plungers that the one in either heating-vessel is stationary in its uppermost position, with the space below it full of heated air, while the working-piston is making the stroke from the end of the cylinder in connection with that vessel, the plunger in the other heating vessel making both its upward and downward stroke in the mean time, and causing the latter vessel to be filled with heated air to produce the return stroke of the working-piston. The gland which is used to compress the packing in the stuffing-box is made with a deep cup in its upper part for the reception of oil, and around the upper edge of this cup is secured a leather collar in close contact with the plunger-rod, so as to prevent the escape of air.

The engine of NAPIER AND RANKINE, patented in the United States, September 19, 1854, and in England June 9, 1853, is of this class.

4. The fourth class includes those which use steam to lubricate the parts; an example will be given, but it is not to be inferred that it is confined to one. The immense expenditure of grease has induced the use, in many or perhaps most of the air-engines, of moistened air as suggested by Glazebrook 1797, Oliver Evans about the same time, and by Bennet 1838.

BICKFORD, June 6, 1865. The air is compressed in the reservoir by an annular piston; entering at the valve *D* during the down stroke, and passing through the piston during the up stroke. It is moistened by passing through a body of water *B*

Fig. 93.



Bickford's Air-Engine.

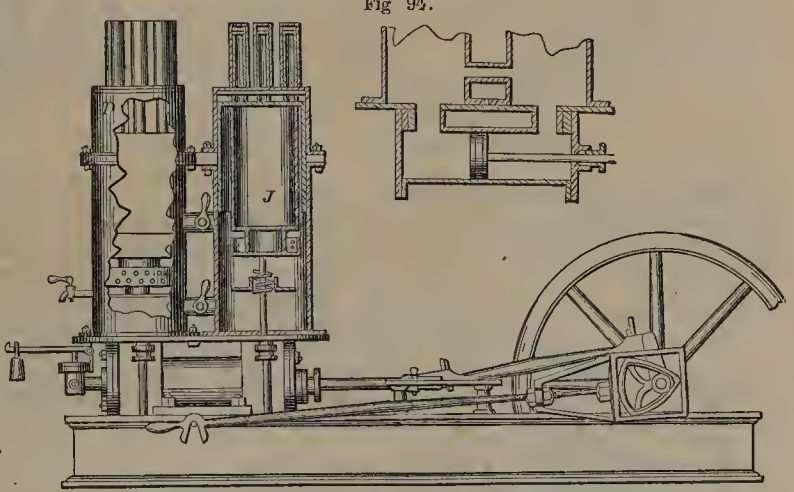
before reaching the compressed-air reservoir *A*. See AËRO-STEAM ENGINE.

5. Of the fifth class is the patent of SHEARER, September 3, 1861; in which two cylinders are used with two pistons, the faces of which are in contact with water, which is caused to pulsate by the action of bodies of air. The air is acted upon alternately by heating and refrigerating means.

KRITZER, July 29, 1862. This invention also belongs to the fifth class.

The working-cylinder, shown in longitudinal section in Fig. 94, is filled with water, which also extends into the lower portion of each of the vertical cylinders above. The lower portion of each upper cylinder forms an air-condensing space. The spaces *D*, above the pistons *J*, are the air-heating spaces where it is made effective. To the bottom of each piston is attached a sprinkling-trough of light metal, with perforated sides, so that at each descent of the piston it will be filled with water, and as it rises will distribute the same upon the inside of the cylinder.

Fig 94.



Kritzer's Air-Engine.

Air'-en'-gine, Com-pressed'. Under the headings AIR AS A MEANS OF TRANSMITTING POWER, COMPRESSED-AIR ENGINE, AIR AS A WATER-ELEVATOR, reference has been made to the use of compressed air as a motor. The devices incident to the application of the air to drive machinery have usually been of a character similar to those of a steam-engine. A piston reciprocating in a cylinder by the impact of the air admitted to the sides alternately, the induction and eduction being governed by valves.

In the Govan Colliery, Scotland, the compressed air is made to drive a high-pressure engine at the

bottom of the shaft. See COMPRESSED-AIR ENGINE. At the Hoosac Tunnel the drills are driven by compressed air, and the same is true of the tunneling-machine used at Mont Cenis Tunnel, lately completed. See TUNNEL.

Air'-es-cape'. An air-trap which allows air to escape from the upper bend of a water-pipe. It consists of a ball-cock, which, in falling a certain extent, opens the air-valve, and closes when the water rises to the level for which it is set.

Air'-ex-haust'er. An air-trap, by which collected air may escape from water-mains, etc.

An air-pump, or vacuum-fan, by which effete air is removed from a shaft, mine, room, or other place.

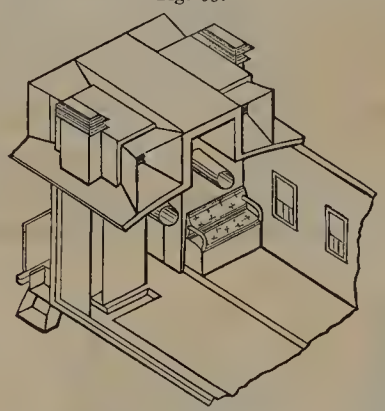
A *vacuum* ventilator in contradistinction to a *plenum* ventilator, which operates by forcing *in* air.

Air'-fil'ter. DR. STENHOUSE'S air-filters were set up at the Mansion House, London, in 1854.

The mode of filtering air is by a wire screen, which arrests floating and flying bodies of any magnitude, and then exposes the current of air to the contact of water.

The most common exemplifications of the devices are to be found in the railroad-car ventilators. In

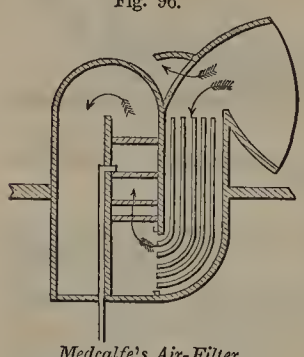
Fig. 95.



Ruttan's Car-Ventilator.

RUTTAN'S patent, January 9, 1866, the air is caught by hoods above the car-roof, and led into a chamber where the plashing water absorbs the dust and also confers upon the air a wholesome moisture. In winter, in addition to this purification, the air is conducted through the heating-chambers of a stove before being disseminated inside the car.

Fig. 96.

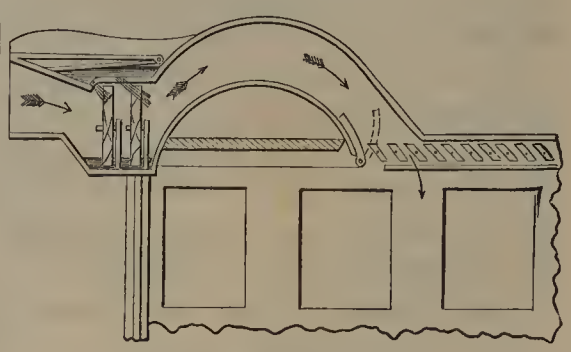


Medcalfe's Air-Filter.

MEDCALFE'S apparatus for ventilating railroad-cars, January 22, 1856. The current of air is received by a self-regulating bonnet on the roof, and conducted by several passages to a water-chamber, whence it passes through a number of fixed wire screens before reaching the interior of the car. The air is carried into the car through registers or by pipes around the stove. From the car it passes through a similar apparatus, devoid of water.

BAUSMAN, April 9, 1861. In the upper part of either end of and extending across the car is placed a trunk or box, having near its orifice a depression which forms a water-chamber, in which are mounted a series of fans, so arranged as to be set in motion

Fig. 97.

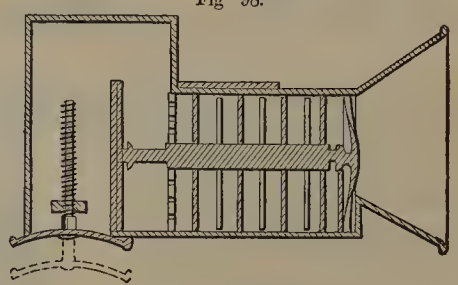


Bausman's Car-Ventilator.

by the resistance of the air as the car moves along. Above the fans is a water-chamber, the bottom of which is perforated to allow the water to drop on the fans. In the rear of the trunk is a register for admitting air to the car, the air being divested of dust in passing through the spray caused by the operation of the fans.

FURNIS, September 17, 1861. Arranged within the flaring mouth of a case is a wind-wheel connected with a shaft. Upon the shaft are secured a series of radiating arms and a perforated disk, which re-

Fig 98.

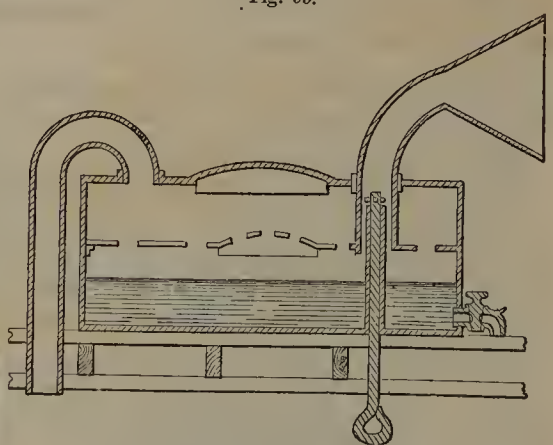


Furnis's Ventilator.

volves in a water-chamber as the car moves along, so that the particles of dust coming in contact with the arms will adhere to the same, and the air enter the car in a cool and pure state.

BEARDSLEY, October 29, 1861. A galvanized iron case contains a reservoir and a perforated plate, and is provided with a funnel-shaped tube, which passes into the ventilator a little below said perforated plate. Another tube passes through the car and enters the top of the ventilator. The funnel-

Fig. 99.

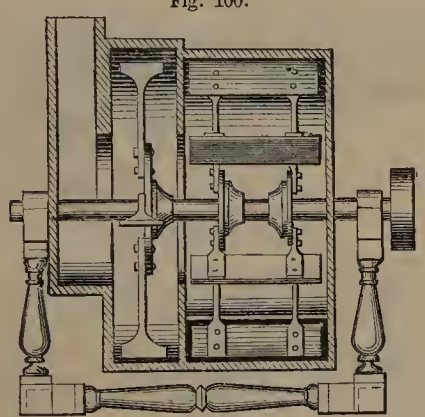


Beardsley's Car-Ventilator.

shaped tube by which the air enters the ventilator is adjusted by means of a rod passing through the top of the car, the open end being turned in the direction in which the car is moving; the other tube receives the foul air from the car, whence it passes through the ventilator. By reversing the funnel-shaped tube the air is ejected from the car. Cinders and dust are prevented from entering the car by coming in contact with the tube, which is surrounded with water.

In WHELPLEY AND STORER'S apparatus for removing dust and gases from air, March 6, 1866, the spray-wheel and the draft-wheel are placed in separate and communicating chambers. The object is to remove the dust and gases from air which issues from the pulverizers and the chimneys of furnaces for

Fig. 100.

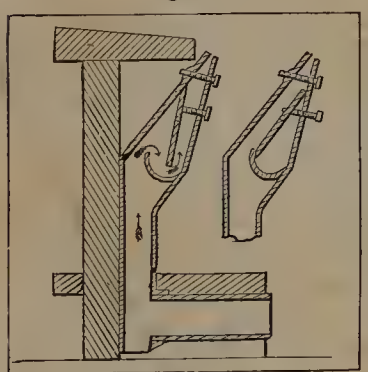


Whelpley and Storer's Draft and Spray Wheel.

reducing metal. The air is admitted by the trunk into the chamber, where it is exposed to a dash of spray from the wheel, and thence passing to the fan-chamber is subjected to jets of liquid, chemically prepared to act upon the gases present. The jets proceed from the hollow shaft, which is pierced with holes for that purpose.

HERRON, January 12, 1858, attaches to the pulpit or rostrum an air-pipe by which a supply of fresh, pure air is afforded to the speaker. The air in its course is passed through a trough and beneath a plate which forms a trap. Water in the trough imparts moisture to the air, and at the same time arrests dust and such extraneous matters or vapors as are soluble in water. The latter may be medicated to impart the desired quality to the reader or speaker, and the valve is adjustable to permit the free exit or turn the current through the water-trough as may be required.

Fig. 101.



Herron's Pulpit-Ventilator.

Air'-flue. A tube by which heated air is conveyed into an apartment.

Air'-foun'tain. A contrivance for producing a jet of water by means of compressed air.

Air'-fun'nel. A cavity formed by the omission of a timber in the upper works of a vessel, to form a duct for the admission of pure air and the escape of foul.

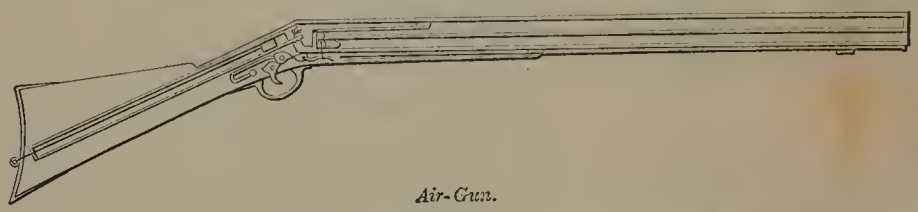
Air'-fur'nace. A term used to signify a furnace having a natural draft, no blast.

Air'-grat'ing. An iron grating in a wall, to allow ventilation.

Air'-gun. The air-gun is a pneumatic engine for firing bullets or other projectiles by force of compressed air. The child's popgun illustrates the principle of the air-gun: a pellet is forced through a tube or quill by a rammer from the larger to the smaller end, where it sticks fast, and another pellet is put in and pressed forward in the same manner, condensing the air between them, when the pressure on the first pellet overcomes its frictional adherence to the sides of the tube, the pellet is released, and is projected by the force of the expanding air. The ancients were acquainted with some kind of an apparatus by which air was made to act upon the shorter arm of a lever, while the longer arm impelled a projectile; and it is said that Ctesiphus of Alexandria, a celebrated mathematical philosopher, who lived B. C. 120, constructed an instrument in which the air, by its elastic force, discharged an arrow from a tube. (Montucla, "Histoire des Mathématiques," Vol. I. p. 267.) The first account of an air-gun is found in David Rivault's "Elémens d'Artillerie." He was preceptor to Louis XIII. of France, and ascribes the invention to a certain Marin of Lisieux, who presented one to Henry IV. of France, about A. D. 1600. An instrument of this kind was invented by Guter of Nuremberg about A. D. 1656. Various shapes have been adopted, from that of the ordinary musket to a gun resembling a common, stout walking-stick. It consists of a lock, stock, barrel, and ramrod; and is provided with proper cocks for filling it with compressed air by means of a force-pump. The lock is only a valve which lets into the barrel a portion of the air compressed in a chamber in the stock when the trigger is pulled. The gun is loaded with wadding and ball in the ordinary way, and when fired there is but little noise, and none of the other concomitants of gunpowder, smoke and odor. The usual range to which the air-gun propels a bullet is from sixty to eighty yards. In those guns having a sliding trigger, two or three bullets are successively and separately introduced, and may be expelled by one mass of condensed air. Air-guns have also been constructed upon the principle of revolving pistols, admitting the expulsion of several bullets after once charging with compressed air. Some varieties have an air-pump attached by means of which a more powerful compression of air may be produced. One air-gun in the form of a cane has two barrels, — one small one for the reception of bullets, and one large bore for the reservoir of compressed air. Elastic springs have also been used in connection with compressed air, but the latest improvements are those of Cornelius Borda. The reservoirs of the gun are filled with a mixture of oxygen and hydrogen in due proportion for producing water. The gun is provided with a small electric battery connecting with the trigger. The moment a portion of the gas is let out, an electric spark is produced, occasioning the instantaneous combustion of the mixture, and a high pressure in consequence of the excessive heat resulting from the chemical transformation. This gun is said to propel a bullet as far as an ordinary musket. The noiselessness of ordinary air-guns is accompanied by slight projectile force, and the gun of Borda in exploding a body of gases in confinement would probably cause as much sound as the combustion of

gunpowder in quantity sufficient to generate the same projective force. SHAW'S air-gun, patented in 1849, combines an endless band of vulcanized india-

Fig. 102



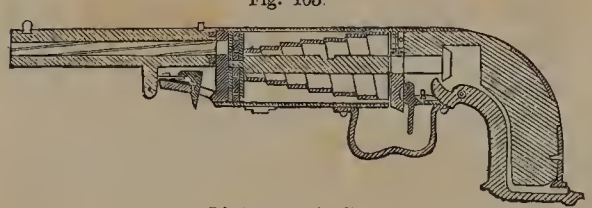
Air-Gun.

rubber with an air-exhausting apparatus; the electricity is so applied as to compress the air at a single stroke of the air-pump the moment before it is discharged. The steam-gun, exhibited in London a few years ago, exemplified a much more forcible agent than air for the propulsion of bullets.

In Fig. 102 the upper chamber is the reservoir of air, which is condensed therein by means of the piston and valve in the stock. The lower tube is the barrel, and the ball is rammed down to its lower end as usual. The gun being sighted, the motion of the trigger moves the valve, which admits a body of air to the rear of the ball and expels it from the barrel.

LINDNER, December 16, 1862. The lever conforms in shape to the stock of the gun, and is the

Fig. 103.

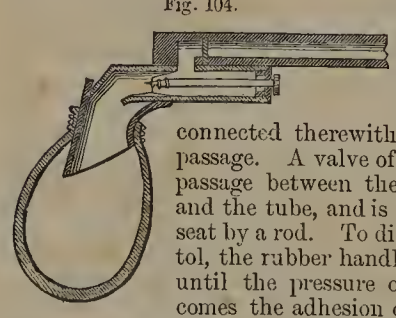


Lindner's Air-Gun.

means of retracting the piston. The piston, when released by the trigger, is driven forward by the elastic force of the condensed spring, projecting the bullet from the barrel by further compression of the air. The spring is a helical ribbon, and condenses into a simple coil when the pressure of the lever is applied. The barrel is breech-loading, tilting on a pivot so as to expose the rear for the reception of the ball, and being locked shut by a catch. A projecting india-rubber ring at the joint of the barrel makes an air-tight joint when the barrel is closed. The projectiles have an expanding portion, which enters the rifle-grooves of the barrel to increase the accuracy of the flight.

GEDNEY, September 24, 1861. The hollow handle is formed of india-rubber or other flexible air-tight material, and communicates with a short tube placed beneath the barrel and connected therewith by means of a passage. A valve of cork closes the passage between the hollow handle and the tube, and is pressed into its seat by a rod. To discharge the pistol, the rubber handle is compressed until the pressure of the air overcomes the adhesion of the valve to its seat, when it is driven back; the air then escapes into the tube and thence into the barrel, driving out the projectile. This and the preceding are only toy-guns.

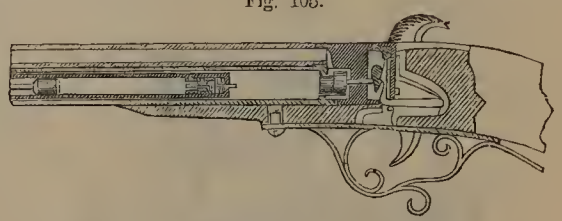
Fig. 104.



Gedney's Air-Pistol.

GIFFORD, February 9, 1864. The barrel is in communication with the inside of the trigger-box, in the interior of which is a valve-piston, consisting of a steel rod carrying a ring fitted with a caoutchouc disk for closing communication. Air enters the barrel by a bell-shaped chamber. By pressing strongly on the extremity of the rod, the disk is compressed and

Fig. 105.



Gifford's Air-Gun.

closes the reservoir orifice. By suddenly releasing the piston-valve the elasticity of the caoutchouc, combined with the pressure of the compressed air, causes the sudden opening of the reservoir orifice and emits a blast of air to the rear of the projectile. The air is compressed into a reservoir beneath the barrel, by means of a piston working longitudinally in a valved interior tube, and the valvular arrangement is to give an instantaneous emission of air and an immediate closure, so as not to waste the air by a protracted opening of the valve-way.

The South American Indians of the Amazon and Orinoco use a species of air-gun or blow-pipe for propelling poisoned arrows. It consists of a long, straight tube in which an arrow is placed and expelled by the breath. Near Pará, it is very ingeniously made of two stems of a palm, of different diameters, one fitted within the other to secure perfect straightness; a sight is fitted to it, near the end. The arrows used are fifteen to eighteen inches long, having a little ball of down, from the silk cotton-tree, twisted round the smaller end so as to make it fit closely in the tube. In the hands of a practised Indian this is a very deadly weapon, and as it makes no noise he frequently empties his quiver before he gathers up his game.

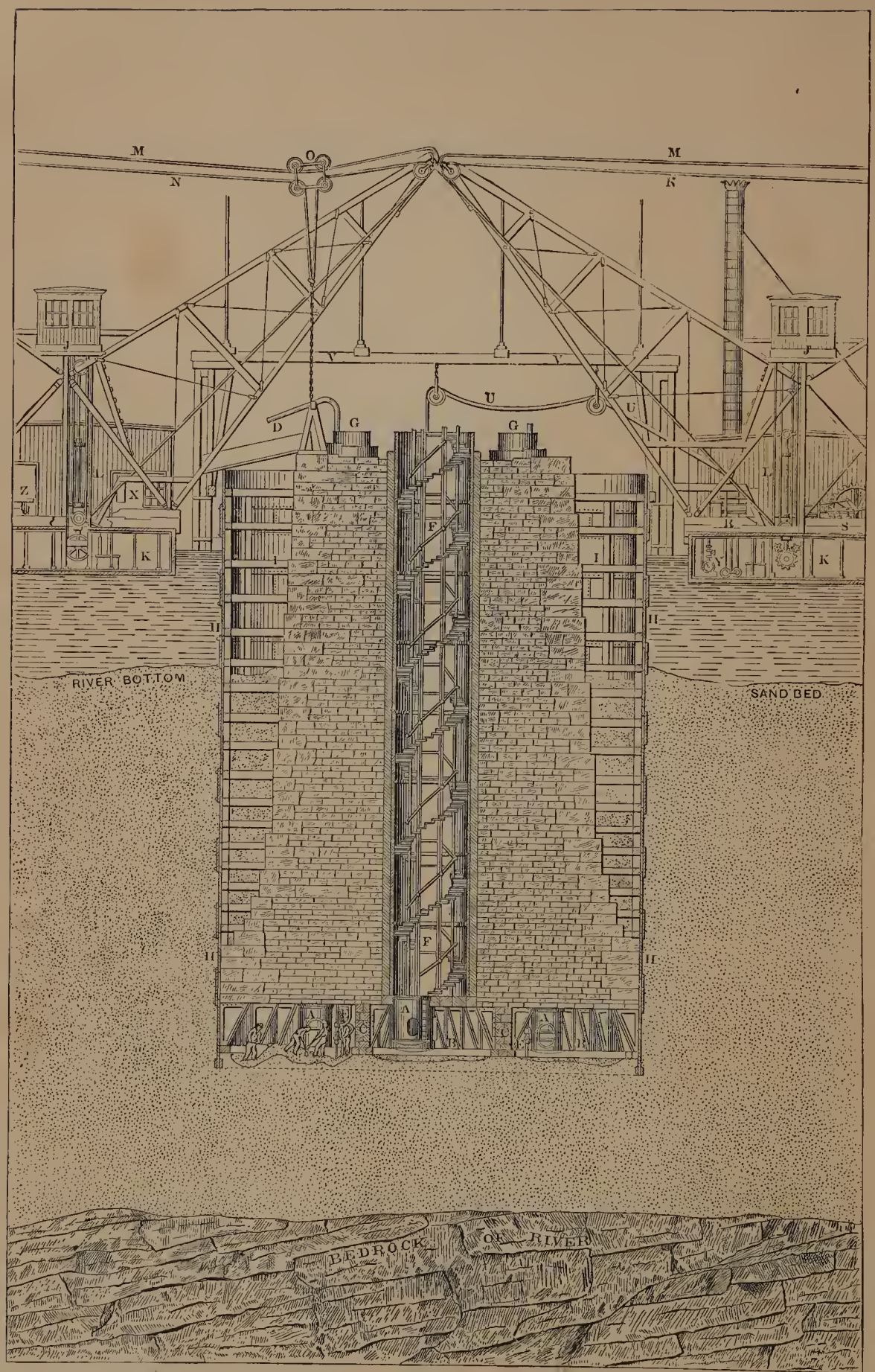
Warburton, the eminent naturalist who wandered in these countries, gives a good account of their modes of hunting. See also Humboldt, and the Researches of Sir Robert H. Schomburgk in British Guiana.

A similar weapon is found among some of the Malay tribes, and is called by them the sumpitan.

Aristotle was acquainted with the fact that the air has weight, stating that a bladder inflated with air will weigh more than an empty one; as he was not acquainted with glass globes, which can be exhausted of air without losing their shape, we may infer that his statement with regard to the bladder was intended to apply to a hypothetical one which possessed the stiffness of glass, or else that the air was considerably compressed in the inflated bladder.

Hero of Alexandria, in his "Spiritalia," shows his knowledge of the elasticity of air, and how it could be used to produce many effects. He shows the air-pump.

Ctesibus developed the pump into an air-gun.



PIER AND CAISSON.

PLATE I

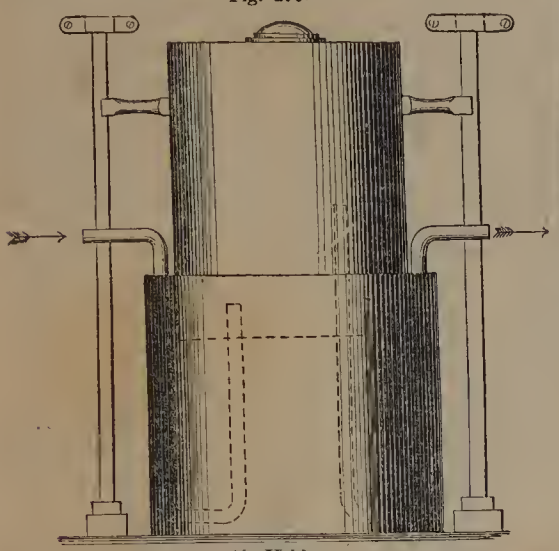
ILLINOIS AND ST. LOUIS BRIDGE.

Page 49.

He was probably the tutor of Hero and the contemporary of Archimedes. Otto Guericke reïnvented and applied the air-pump; Boyle made it a valuable instrument.

Air'-heat'er. A stove or furnace so arranged as to heat a current of passing air, for warmth or ventilating purposes. See HEATING FURNACE; HEATING STOVE; HEATING APPARATUS, etc.

Fig. 106.



Air-Holder.

Air'-hold'er. A vessel generally of a cylindrical form, with its open end plunged in a tank of water, and intended to contain air or gas. Its use is common in a variety of machines and apparatus where a steady and moderate current of air is required, as in machines for carbureting air and gas, aspirators, etc. Also in machinery on a larger scale, such as blowers, ventilating-machines, etc.

The air is introduced by a bent pipe turned upward inside the tank and holder, and is educed in a similar manner. On a small scale the vessel may be charged with air by raising the upper valve and lifting the holder, and the air may be withdrawn by a flexible pipe attached to the holder. See ASPIRATOR; CARBURETING AIR; BLOWER, etc.

Air'-hole. (*Founding.*) A hole or cavity in a casting produced by bubbles of air in the liquid metal. A vent-hole in a mold for casting.

(*Furnace.*) A draft-hole in a furnace. It is sometimes guarded by a register; sometimes stopped by a luting or plug of clay.

Air'ing-stage. A platform on which powder, etc., is dried by exposure to sun and air.

Air'-jack'et. An air-tight swimming-jacket capable of inflation.

A garment with inflatable lining or pockets to serve as a life-preserver.

Air'-lev'el. (*Surveying.*) A goedetic instrument invented by M. Thevenot. The level is determined by means of an air-bubble in a glass tube nearly filled with colored spirit. Generally termed a spirit-level; though the air-bubble is the dominant feature. See LEVEL.

Air'-lock. (*Hyd. Eng.*) A pneumatic contrivance in a hollow caisson whose lower chamber is filled with compressed air to exclude the water. A trunk connects the submerged chamber with the external air, and has two valves. The descending workman enters a chamber in the tube at the atmospheric pressure; the upper valve is closed, and his apartment is charged with air from the lower chamber; the lower valve is then opened to admit him to the working-chamber.

Plate I. is a sectional view of the East Pier and Caisson of the Illinois and St. Louis Bridge, in course of construction by Captain James B. Eads, across the Mississippi. The view shows the interior of the main entrance-shaft and air-chamber, and the working of one of the pumps. The caisson is represented as having descended through 60 feet of sand, silt, and gravel which form the sand-bed of the river; 20 feet of excavation remaining before the bed-rock is reached.

The pier of masonry is built on a strong bulkhead of timber and iron, supported on a curb which rests on the sand-bed, and is strengthened and sustained by timber girders which divide the working space beneath into several chambers which communicate through holes in the partitions. The pier is enclosed by an iron envelope *H*, which is water-tight, and prevents access of water to the pier and the workmen. Until the curb of the caisson reached the sand-bed it was sustained in erect position by screws from the trusses of the guide-piles, but was afterwards preserved erect by digging away the sand equally at all the points upon which it rested. *I I* are timber braces which support the shell *H*. *K K* are pontons alongside, which support the steam-engine, air-pump, mixing and hoisting machinery, and the offices and quarters for the staff and hands. *S* is the steam-engine which drives the air-pump *R*, and the air is conducted by the hose *U* down to the chambers *B B*, where the excavating is proceeding. The sand is loosened by water and the pick, and is driven by condensed air up through the sand-pumps *E E*, which discharge at *D*. The air-locks *A A* are chambers intervening between the main entrance-shaft *F*, where the air is at the natural pressure, and the chambers *B B*, where it is in a much condensed condition. The visitor steps from the shaft *F* into the air-lock *A*, the door of ingress is closed, and condensed air is then admitted. When an equilibrium is established between the chambers *A* and *B*, the door between is opened, and the visitor finds himself on the scene of action. As the caisson descends, successive courses of stone are laid on the piers by means of traveling-purchases *O*, which move on the wire ropes *M M* by means of hoisting-ropes *N N*. *G G* are side shafts; *J J* cabins for operators of purchases; *L L* hydraulic jacks for lifting materials; *Y* pipe for water to sand-pump; *V V* trusses for guide-piles; *Z* mixing-room; *X* office. See CAISSON.

Air'-ma-chine'. A machine for ventilating mines.

Air'-met'er. An apparatus for measuring the quantity of air passing along a pipe, or passing into or from a chamber.

There are various forms: the fan, rotating spiral vane, expanding bag, cylinder and piston, revolving partially submerged meter-wheel, etc. As their principal adaptation is to measuring gas, to avoid unnecessary repetition they are assembled under GAS-METER, which see.

Air'o-hy'dro-gen Blow'pipe. An apparatus invented by Dr. Hare, in which the issuing air is assisted by a jet of hydrogen to intensify the flame. See BLOWPIPE.

It is especially used in autogenous soldering.

Air-om'e-ter. The term is applied to a hollow cylinder, closed above and open below, with its lower edge plunged in a tank, and used to contain air. The term has been derived from its similarity in shape to a gasometer, the change in the first syllable indicating the different contents. Its use as a meter is unfrequent, and it is prop-

erly called an air-holder among experts. See AIR-HOLDER.

Air'-pipe. (*Steam-engine.*) 1. A small copper pipe leading from the top of the hot-well through the ship's side, for the discharge of the air and uncondensed vapor removed by the air-pump from the condenser.

2. A pipe used to withdraw foul air from or force pure air into close places.

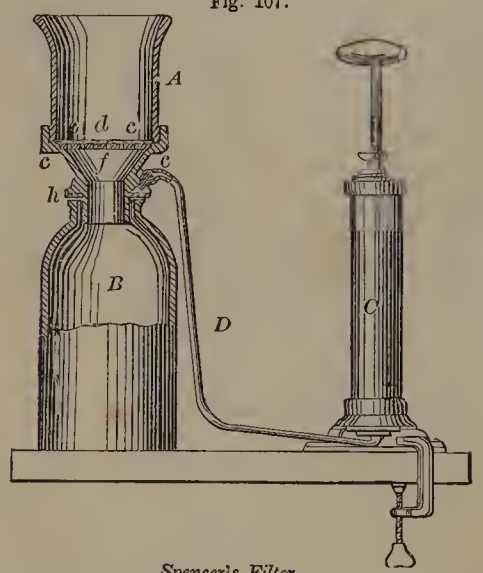
Air'-poise. An instrument to measure the weight of air.

Air'-port. An opening in a ship's side for air; closable by a shutter, side-light, or dead-light, according to circumstances.

Air'-press'-ure Fil'ter. A filter in which the percolation of the liquid is assisted by atmospheric pressure, induced by a partial vacuum in the lower chamber.

SPENCER'S air-pressure filter, June 4, 1867, is particularly adapted for the use of pharmaceutists. *C* is the air-pump, secured by a clamp to the edge

Fig. 107.



Spencer's Filter.

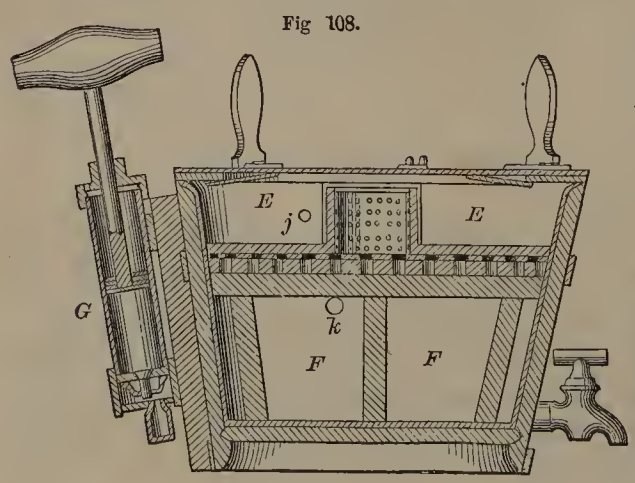
of the table. The filter *A* rests on a packing on the lip of the bottle *B*. The air is withdrawn from this latter to increase the rate of filtering.

Claim.— First, in an atmospheric filter composed of the tunnel *A*, bottle or jar *B*, and air-pump *C*, the employment of a packing *h* for the purpose of producing an air-tight joint between the tunnel and bottle, the whole combined and operating as herein set forth.

Second, the arrangement of the filtering medium *d d* with the removable perforated diaphragm *f*, when operating in connection with the shoulders *c c*, as herein set forth.

D is the air-eduction pipe. The vessel *A* stands in the collar-piece *f*, the latter on the bottle, whose lip has a packing-gasket.

Fig 108.



Gruber's Filter

In GRUBER'S air-pressure filter, April 3, 1866, the filtration is assisted by an air-forcing and air-exhausting pump, connecting by pipes with the two chambers separated by the filtering substance. *j* and *k* are the openings of the plenum and vacuum pipes into the chambers *E* and *F*. The lid is fastened on, and has an air-tight packing. The pump *G* draws air from chamber *F*, and impels it into chamber *E*. For WATER-PRESSURE FILTER see PRESSURE-FILTER.

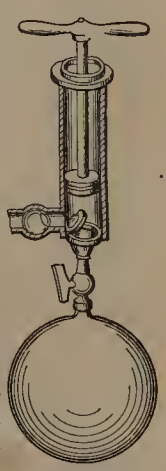
Air'-pump. Invented by Ctesibus of Alexandria, or previous to his time. Hero, of the same city, the author of the "Spiritalia," shows it in connection with several of his pneumatic contrivances. He also shows a fire-engine with a pair of single-acting pistons attached to a walking-beam and operating alternately in their respective cylinders.

February 15, 1665, Mr. Samuel Pepys, the gossiping author of the famous Diary, was admitted a member of the Royal Society, the meetings of which were held at Gresham College. He says:—

"It is a most acceptable thing to hear their discourse, and see their experiments; which were this day on fire, and how it goes out in a place where the ayre is not free, and sooner out when the ayre is exhausted, which they showed by an engine on purpose. . . . . Above all Mr. Boyle was at the meeting, and above him Mr. Hooke, who is the most, and promises the least, of any man in the world that I ever saw."

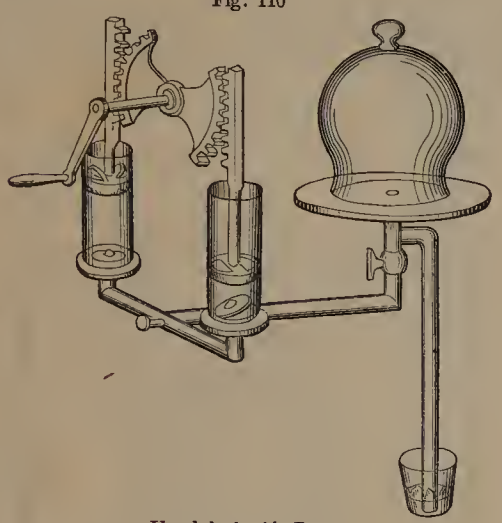
The air-pump was reïnvented by Otto von Guericke of Magdeburg, about A. D. 1650. Since then this instrument has been much improved by Hooke, Papin, Hawksbee, and Boyle. Many varieties of structure have been devised, the principle of all being the same. The basis or essential part in the air-pump is a metallic or glass tube answering to the barrel of a common pump or syringe, having a valve at the bottom opening upwards; and a movable piston or embolus, answering to the sucker of a pump, the piston or cylinder being furnished likewise with a valve opening outward. The pump must be closely fitted by a metallic connecting-tube opening into or under the vessel which is to be exhausted, which is usually formed by placing a bell-glass, called the receiver, with the edges ground smooth, and smeared with lard or wax, on a flat, smooth plate or table. When the piston is at the bottom of the barrel, and is then drawn up, it lifts out the air from the barrel; and a portion of the air from the receiver by its own expansive force passes through the connecting-tube, and occupies the place below the piston which would otherwise be a vacuum. The air in the receiver and barrel is thus rarefied; the piston is now forced down, closing the valve placed at the mouth of the connecting-tube, and causing

Fig. 109.



the air in the barrel to escape through the valve in the piston. This operation is again and again repeated until the receiver is so nearly exhausted that the elastic force of the remaining air is no longer sufficient to open the valves. The form of the pump may consist of two barrels (each having a piston) having a junction with each other at the point where the connecting-tube is attached, and operated alternately by a lever attached to each piston and supported at a point midway between them, or by means of teeth or cogs cut in the piston-rod, and operated by a cog-wheel, as shown in the accompanying figure. The valves may be made of bladder, oiled silk, or gutta-percha, the best form of which is a small hollow cone with a slight cut at the top; stop-cocks must be attached so as to control the admission of air. The pressure of the atmosphere being about fifteen pounds to every square inch of surface, care must be taken that the receiver and barrels of the pump

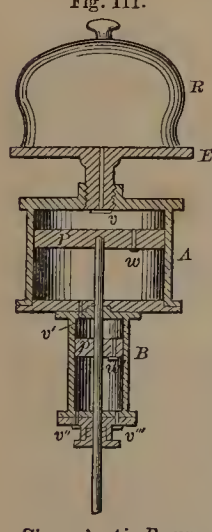
Fig. 110



Hawksbee's Air-Pump.

be so constructed as to bear this weight without accident. A gage to ascertain the point of rarefaction can be made by introducing the lower end of a graduated glass tube, connecting with the receiver, into a cup containing mercury; as the air in the receiver is exhausted, the pressure of the atmosphere on the surface of the mercury will force it up into the graduated tube, so that its rise and fall will indicate the rarefaction. A perfect vacuum can never be made, for it is evident that the exhaustion can never be complete; even theoretically, there must always be a portion of air left, though that portion may be less than any assignable quantity. Many useful and interesting experiments can be performed with the air-pump, illustrating the effects of atmospheric pressure and other mechanical properties of gases.

Fig. 111.



Siemen's Air-Pump.

In SIEMEN'S air-pump the two cylinders or barrels differ in size and arrangement. The smaller barrel is applied either to the bottom or top of the larger, while the valved pistons belonging to each are attached to one and the same piston-rod. The air withdrawn from the receiver is condensed in the lower cylinder to one fourth of its original volume, and thus has sufficient elasticity to pass through the discharging valve and escape, the opposing pressure of the atmosphere on that valve being thus counteracted from within.

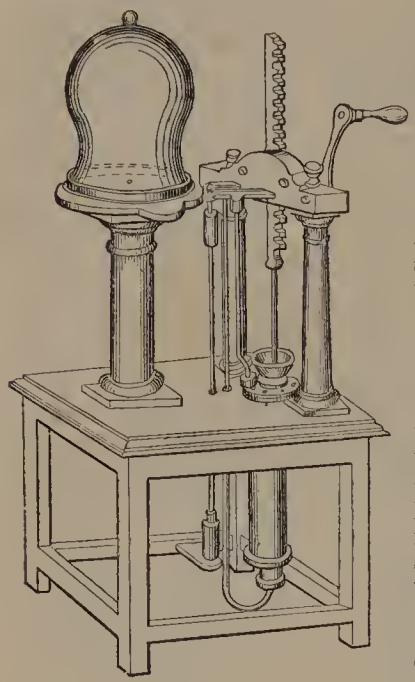
In the illustration, *A* is the exhausting-cylinder, *B* the second cylinder, equal in length to the first, and fixed to its lower part, but having only one third or one fourth of its sectional area, and consequently one third or one fourth of its cubical contents. The cylinders are separated by a plate forming at once the bottom of the upper and top of the lower cylinder, the only passage between them being a silk valve *v'*. In each cylinder works a valved piston, *P* and *p*, attached to a piston-rod common to both, and passing through a stuffing-box in the plate. The distance between the pistons is such, that when *P* is in contact with the top of the upper or exhausting cylinder *A*, *p* is in contact with the top of the smaller or lower cylinder; and when *P* is in contact with the bottom of the large cylinder, *p* is in contact with that of the small cylinder. The table or pump-plate *E*, placed above the large cylinder *A*, supports the receiver *R*, or other vessel to be exhausted, from which the air flows through the valve *v*, during the descent of the piston. The motion of the pistons is effected by means of a short crank with a jointed connecting-rod, converting the circular motion given by the lever-handle into a vertical one, which is maintained by means of a cross-head, with rollers working between guides. The action of the pump is as follows: The descent of the piston *P* tends to produce a vacuum in the exhausting-cylinder *A*, by causing a difference of pressure above and below the first valve *v*, in the top of *A*, so that the elasticity of the air in the receiver causes it to pass through the valve *v*. At the same time the air below *P* is pressed through the valve *v'*, in the plate which separates the cylinders, and enters *B*, in which a vacancy is simultaneously made for it by the descent of the piston *p*; and in consequence of the difference of capacity of the two cylinders it becomes reduced to one fourth of its original bulk, its elasticity being proportionally increased. The air contained in the small cylinder below the piston *p* will in like manner be pressed through the valves *v''* *v'''* into the external atmosphere. During the ascent of the pistons the valves *v* *v'* will be closed and *w* *w'* opened by the downward pressure of the air in the cylinders, and *v''* *v'''* will be closed by the atmosphere, thus allowing the air in each cylinder to pass through the pistons as they rise, in order that in the following downward movement the air, which during the previous stroke of the pump issued from the receiver into the exhausting-cylinder, may be withdrawn from that into the lower cylinder, while the air condensed in the latter may be finally expelled into the atmosphere. See AIR-COMPRESSING MACHINE.

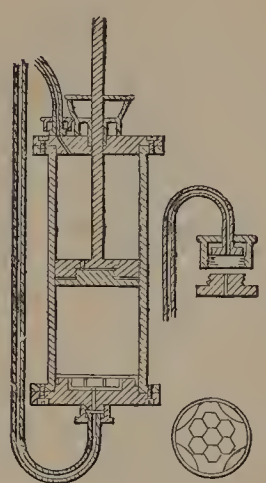
The air-pump of Boyle was inconvenient, as it demanded alternate opening and shutting of the stop-cock and valve, and difficulty was also experienced in making the piston descend when the air within the pump was greatly rarefied.

HAWKSBEE'S air-pump, previously cited, had the duplicate cylinders, with pistons which were moved by means of a crank and pinion. The piston-rods were toothed racks, which were engaged by the pinion, to which a reciprocating rotary motion was imparted. The bottom of each cylinder communicated by a pipe with the receiver on the platform.

SMEATON'S air-pump was an improvement on Hawksbee's in two respects. Hawksbee had found considerable difficulty in opening the valves and ex-

Fig. 112.

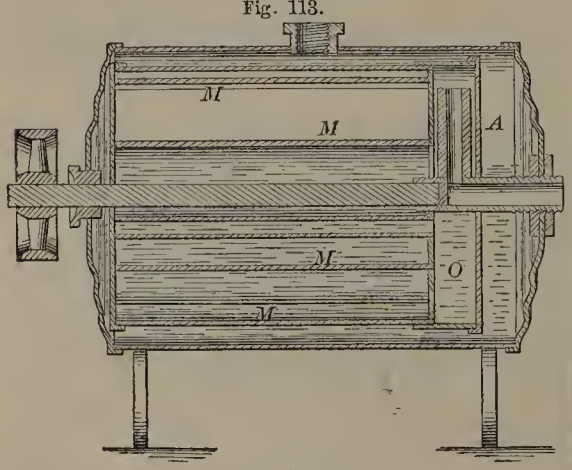




Smeaton's Air-Pump.

hausting the air at the bottom of the barrels, owing to the fact that the pistons did not shut down close on to the bottom. The first defect arose from the smallness of the orifice in the bottom of the cylinder through which the air entered; the bladder being kept moist with oil adhered to the metal and resisted the upward pressure at so small an opening. This defect Smeaton cured by exposing a greater surface of bladder to the upward action of the air. He used a congeries of holes consisting of six hexagonal openings surrounding a central one. The partitions between these holes were filed nearly to an edge, and the whole formed a grating on which the bladder-valve lay, offering but slight cohesive opposition to the raising of the valve as the piston ascended and the air from the receiver pressed upward against it.

Fig. 113.



Rotary Air Pump.

To prevent lodgment of the air in the lower part of the barrel, he removed the external pressure from the piston-valve, by making the piston move through a collar of leather, and forced the air out by a valve applied to the plate at the top of the barrel, which opened outwardly.

Cuthbertson of Amsterdam introduced the improvement of mechanically opening an escape for the air without depending upon its elastic force to open the valve leading to the cylinders.

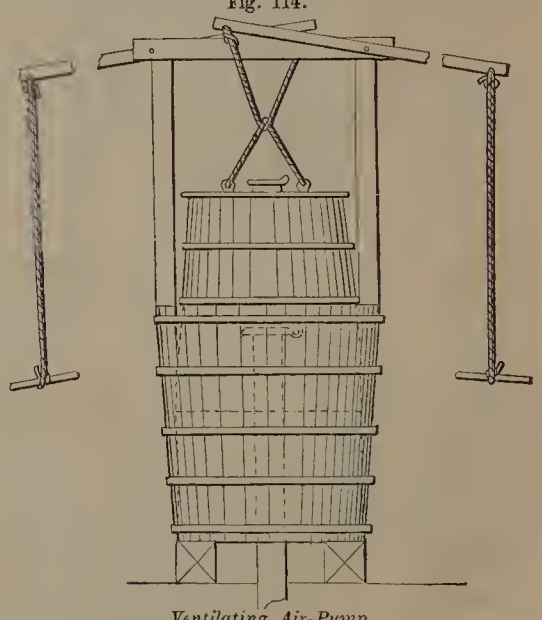
Air force-pumps are used for the supply of air-carbureting machines. A common form of these consists of what is called a meter-wheel, from its resemblance to the measuring-wheel of a gas-meter. Fig. 113. In the illustration the buckets *M* are curved, and gather in the air of the chamber *A*. As the wheel rotates the air is discharged, near the axis, into chamber *O*, and is conducted by a pipe to the hollow trunnion through which it is discharged.

Another form of air-pump used in carbureting-machines is on the principle of the gravitating air-holder, which consists of a weighted inverted cylinder whose lower edge is submerged in a tank. See AIR-HOLDER.

A conversely acting device on a larger scale is used for pumping air from mines.

In the *Annales des Ponts et Chaussées*, an air-pump

Fig. 114.



Ventilating Air-Pump

is described, used to ventilate a shaft 5 feet in diameter and 220 feet deep. The work had been several times suspended, owing to the accumulation of carbonic acid gas, and the ordinary bellows had been found ineffectual.

A large tub (Fig. 114) was firmly placed on balks on a level with the top of the shaft, and filled with water nearly to the brim.

An air-tight pipe from the bottom of the shaft was brought through the tub, and had its upper edge a very few inches above the water; it had a valve on the top.

A smaller tub, reversed, was suspended within the lower tub by cords, which were made fast to the ends of the levers.

The upper tub had a very short pipe at top, with a valve opening upward.

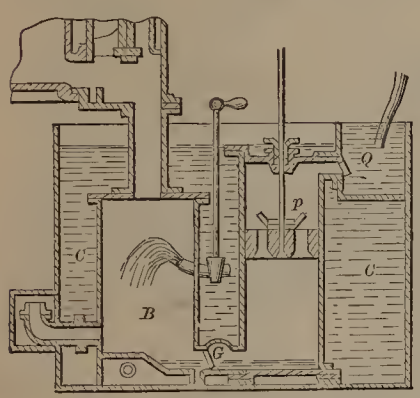
The upper tub being allowed to descend by its own weight, the air within it was expelled through the upper valve; when again raised, by pulling the

handles attached to the ropes, the air was drawn up through the valve-way at the upper end of the descending tube, and by continuing this reciprocating action, a circulation was created at the very bottom of the shaft.

Bunsen's air-pump is a means of withdrawing air by entangling and carrying it with a falling body of water. It is specifically known as an aspirator in its uses to obtain atmospheric pressure in filtering, in removing effete or poisonous air from apartments or the vicinity of gangrenous wounds. See ASPIRATOR. The same principle is involved in the "water-pumps," so called, which withdraw the air and steam from the evaporating and vacuum pans of sugar-refineries, the injection-chamber of the condensing steam-engine, etc. Air-pumps are also constructed to act on the principle of the Giffard Injector, the active column being a body of water or steam. See STEAM-JET; EJECTOR.

Apparatus for compressing air as a motor, as a water-elevator, etc., are considered under several heads. See AIR AS A WATER-ELEVATOR; AIR-COMPRESSING MACHINE; AIR AS A MEANS OF TRANSMITTING POWER; AIR-ENGINE, etc.

Fig. 115.



Air-Pump.

2. (*Steam-engine.*) A pump used in condensing steam-engines to remove the air and uncondensed steam from the condenser in order to perfect the vacuum therein, and in the cylinder to which it is periodically connected.

B is the injection-chamber, which is submerged in the cistern *C*. The uncondensed gases and water escape by the valve-way *G*, called the foot-valve, and ascend through the valve of the pump-bucket *p* as the latter descends. The next ascent of the bucket drives them out at the valve-way *Q* into the hot-well.

Air-reg'u-la'tor. A contrivance for determining the quantity of air admitted in a given time.

Registers and dampers are the usual devices; the former has usually a sliding and the other an oscillating motion. Furnaces, stoves, ovens, etc., are usually furnished with some means for regulating the supply of air; when the heat of the stove is made to regulate the register the device is called a THERMOSTAT (which see).

Air-regulators may be made to act on the principle of the gas-regulator, the degree of pressure determining the area of the opening, so that a given quantity may pass in a given time irrespective of the pressure.

Air'-scuttle. (*Ship-building.*) An opening in a ship's side for the admission of air, closed in stormy weather by a shutter.

Air'-shaft. A shaft in a mine, usually vertical, or nearly so, by which the mine is ventilated.

Air'-spring. An elastic device depending for its action upon the tension of an imprisoned body of compressed air.

Air-springs have been made to act as brakes, to receive recoil of guns, as buffers, and for other purposes. See PNEUMATIC SPRING.

Air'-stove. A heating stove which is employed to heat a stream of air directed against its surface. Of this class are *Heating Furnaces*, and some kinds of *Heating Stoves*.

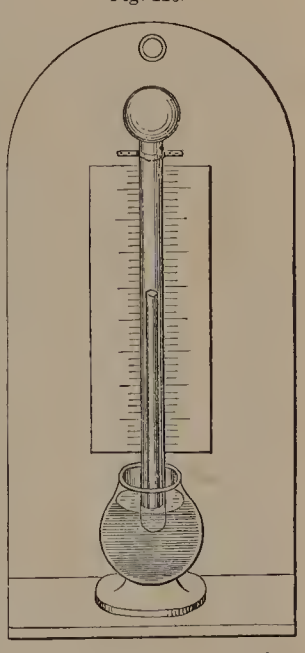
There are two common forms, with a great variety of each: —

1. The furnace such as is used in churches, large halls, and some dwellings; consisting of a stove surrounded by a casing of metal or brickwork, into which the air is led, and from which, after being heated, it passes by air-ducts to the apartment. See HEATING FURNACE.

2. A stove, a part of whose interior is occupied by passages in which air circulates against the fire-chamber and back, after which it is discharged into the room. See HEATING STOVE.

Air'-ther-mom'e-ter. An instrument in which the contraction and expansion of air is made the measure of temperature. It differs from the ordinary thermometer, which depends on the contraction and expansion of liquid in an hermetically sealed tube. The air-thermometer is the older form, and its invention is variously ascribed to Drebbel of Holland, about A. D. 1600; to Galileo; and to Santorio of Padua (1561–1636). The instrument was constructed as follows: The air in a tube being slightly rarefied by heat, the lower end was plunged into a colored liquid, which, as the air cooled, was drawn into the tube. The expansion and contraction of the air, by changes of temperature, varied the height of the liquid in the graduated tube. It was a faulty arrangement, as changes in the atmospheric pressure would vary the result, and the truth could only be ascertained by correction with reference to a barometer.

Fig. 116.



Air-Thermometer of Santorio.

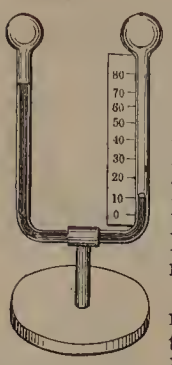
In the "Spiritalia" of Hero, B. C. 150, an instrument is described wherein water is made to rise and fall by the changes of temperature. The Spanish Saracens used a form of hydrometer to detect variations in temperature. See AREOMETER; HYDROMETER; THERMOMETER.

Heat expands the air, forcing down the liquid, and cold has the contrary effect. The temperature is thus indicated by the height of the liquid in the tube.

STURMIUS'S differential air-thermometer consists of two bulbs united by a tube which is bent to form two legs, against one of which is attached a graduated scale. A quantity of sulphuric acid colored with carmine is introduced into the tube so that its upper surface corresponds with zero on the scale. The ball above the scale is termed the focal ball.

The amounts of air in the respective ends are so adjusted that when the bulbs are both exposed to the same temperature the liquid will fill one leg and the horizontal portion of the tube, the level of the graduated tube standing at zero. When both the bulbs are exposed to the same temperature no change takes place in the position of the liquid;

Fig. 117.



Differential Air-Thermometer.

but when the focal ball is exposed to heating or cooling causes, the air will expand or contract, and the column of liquid in the graduated leg will ascend or descend as the case may be. This thermometer is particularly adapted for ascertaining the particular degree of heat accumulated at a particular point, while the surrounding atmosphere is but little affected, as in the focus of a reflecting mirror, etc.

Leslie, in his experiments on heat, made great use of this differential thermometer. By coloring the focal ball and leaving the other white, silvering or gilding one of the balls, covering one with a moistened envelope, etc., he constituted the instrument a photometer, æthrioscope, hygrometer, etc.

Air is more equable in its expansion than mercury with equal increments of temperature.

The following shows the indications on the two scales at the same temperatures; correction being made for the expansion of the glass.

Air Thermometer.	Mercurial Thermometer.	Difference.
°	°	°
212.00	212	0.00
299.66	302	2.33
386.69	392	5.31
473.09	482	8.91
558.86	572	13.14
662.00	680	18.00

In effect, however, the expansion of the glass is about equal to the increase of the rate of the expansion of the mercury, so that the mercurial glass thermometer is accurate as high as 662°.

For temperatures above the boiling-point of mercury, air-thermometers are used. Dry air, when confined, increases in volume $\frac{3}{8}$ for every 180°, and is believed to be perfectly equable in its rate of expansion.

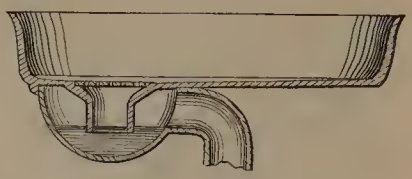
A bulb or cylinder with a tube of platinum is connected to a glass tube at right angles therewith. The glass tube is of uniform bore, is filled with mercury, and terminates below in a recurved bulb. The glass tube is divided into a number of spaces, each equivalent to $\frac{3}{8}$ of the total volume of the platinum bulb or cylinder, with $\frac{3}{4}$ of its stem. The other $\frac{1}{4}$ is supposed to be beyond the immediate influence of heat. The platinum bulb and $\frac{3}{4}$ of its stem are plunged in the furnace, and the depression of the mercury by the heated and expanded air within the instrument pressing on it more powerfully than the external air, will indicate the degree of temperature. Each degree of the glass stem is equal to 180° Fah.

Air'-trap. Sometimes called *stench-trap.* It is an adjunct to a vessel of any kind, such as a washbowl, water-closet bowl, urinal, or sink, which discharges by pipes or sewers up which a current of foul air is liable to pass.

Some of them are very simple in their character, and consist of a water-pan in which is submerged the end of the discharge-pipe of the bowl above. This shuts off the passage of air, and an overflow is afforded to the water as it reaches a certain height.

Craigie's sink, July 2, 1867, is of this character, and its essential feature has been familiar to builders and housekeepers for many years. In the illustration the novel feature is found in the mode of attaching the trap-cup to the bowl and the discharge-pipe to the bend of the cup.

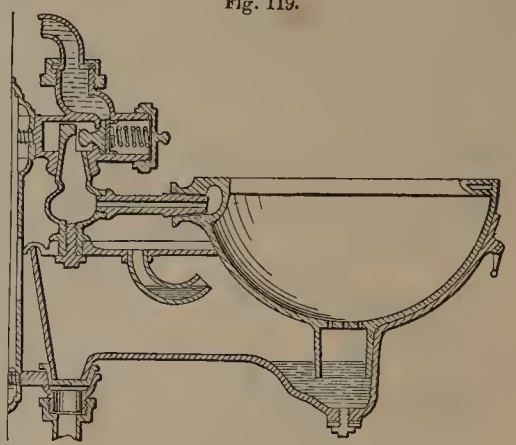
Fig. 118.



Craigie's Sink.

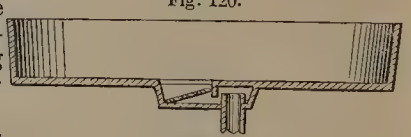
Carr, December 6, 1864. A spout, continuous from the bottom of the basin, descends into the water held in a depressed part of the receptacle. The flow of water into the upper part of the basin is regulated by a valve controlled by a cam movement. The drip from this flow, falling upon the top of this receptacle, is conducted by flanges to a descending tube, which is turned upward within the receptacle, so as to form an inverted siphon, and thus deliver its water into the receptacle without permitting the gas to ascend.

Fig. 119.



Carr's Urinal.

Fig. 120.

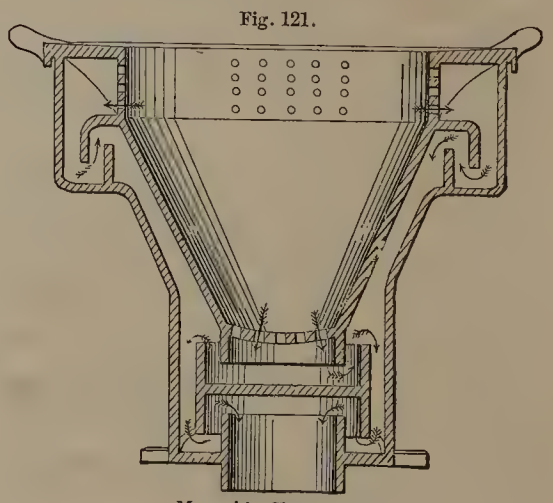


Carson's Sink.

Carson, September 25, 1860. A perforated plate opposes the passage of matter likely to choke the pipe, which enters a chamber beneath the sink. The water passes to the chamber beneath a plate whose edge is submerged in liquid and forms a trap.

Marquis, September 4, 1866. A double trap is

Fig. 121.



Marquis's Slop-Hopper.

formed by compelling the water to pass by a sinuous course through a circular pan and then through an annular pan, on its way to the discharge-pipe.

Air'-trunk. A pipe or conduit for conducting foul or heated air from a room, theatre, or ward.

Air'-tube. A small, wrought-iron tube hung in a coal-box from the deck, and filled with water, for the purpose of ascertaining the temperature of the coals by a thermometer, as a precaution against spontaneous combustion.

Air'-tube for conveying Letters, Goods, and Passengers. This idea suggested by Dr. Papin about 1695, patented by Medhurst in England 1810, on the air-compression principle, and by Vallance in 1824 on the exhaust principle, has come into operation to some extent, and is considered under the head of PNEUMATIC TUBE (which see).

Air'-valve. (*Steam-Engine.*) A valve in a steam-boiler, which opens inwardly to allow air to enter when the internal pressure is below the atmospheric. This may be produced by the condensation of steam when the fire is drawn, and the device is to prevent collapse of the boiler.

Air'-ves'sel. An air-reservoir ; it is applied to those air-chambers from which the air is to be drawn for use, as in carbureters, and one form of air-pump. See AIR-HOLDER.

A chamber on the ejection-pipe of a pump, to render the stream continuous. See AIR-CHAMBER.

Aisle. (*Arch.*) A side-division of a church, partially separated from the nave and choir by columns.

Aitch'-piece. (*Mining.*) The part of a plunger-lift in which the clacks are fixed.

A-jambe'. A French window with four casement windows, separately hinged and fastened.

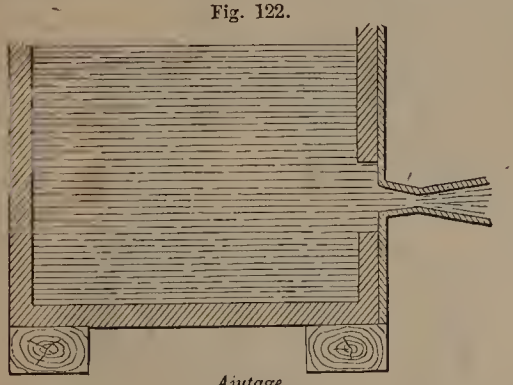
Aj'u-tage. 1. The spout or nozzle of a funnel.

2. A tube applied to the sides of a discharging orifice in a vessel, in order to obviate the resistance to the discharge incident to the contraction of the fluid vein. This resistance may amount to 0.45 of the whole theoretical delivery.

The addition of a cylindrical tube to the opening will cause a greater discharge, the head and sectional area remaining the same.

If the ajutage be cylindrical, and the water fill it entirely, the increase in the discharge, when the length of the ajutage does not exceed four times its diameter, is in the proportion of 1.33 to 1.00.

Fig. 122.



Ajutage.

The effective discharge may be still further increased by making the ajutage of the form represented by the accompanying figure, provided the liquid fill it entirely. This ajutage is composed of two portions of cones upon the same horizontal axis ; the first has the form of the contracted vein, the length of the second is three times that of the first, and the opening into the tube from the chamber is $\frac{7}{8}$ of the size of the delivery opening. The effective discharge through an ajutage of this description is generally stated to be in the proportion of 3 to 2 of that which would take place through an orifice in a thin plate.

Venturi gives the following data : —

Orifice of delivery	0.0338 *m.*
Orifice of entry	0.0406 *m.*
Angle of sides of external tube .	5.6°

The length nine times the diameter of the effective opening.

He found the discharge to be increased to 1.46 times the theoretical discharge, and 2.4 times the discharge that would have taken place had the orifice been in a thin plate.

Al'a-bas'ter. 1. A species of marble, white or colored. Sometimes called Oriental alabaster, to distinguish it from

2. A granular, compact, semi-pellucid gypsum which is found in masses, white or colored, and is readily turned into vases and ornaments.

A-larm'. An audible warning. Alarms, mechanically considered, are of many kinds ; the purpose or construction of each is usually indicated by its name. They are placed in such positions or under such circumstances as to give warning of danger or to call attention.

Marine Alarms are fog-bells, whistles, and trumpets, operated by the tide, the waves, the current, the wind, or by clock-work.

Shoal Alarms are similarly actuated, being situated on spits or banks, anchored, moored, or attached to piles.

Nautical Alarms, on shipboard, are to indicate a leak or the accumulation of bilge-water.

Burglar Alarms are attached to doors or windows to give notice of surreptitious entrance by thieves.

Fire Alarms are actuated automatically by thermostatic arrangements, and give notice of fire, as their name indicates.

Clock Alarms are attached to timepieces to strike an alarm at a given hour.

Gas Alarms indicate an escape of gas, either in a room, or from the fissures in a coal-mine.

High-pressure Alarms are for indicating a dangerous pressure of steam in the boiler.

Low-water Alarms are for indicating the subsidence of the water-level in the boiler below the point of safety.

A *Pocket Alarm* is to notify a person of the abstraction of a book, etc. from the pocket.

Telegraphic Alarms are to call the attention of the operator to his instrument.

Till, *Trunk*, *Safe*, *Lock*, and *Door Alarms* are to call attention to the opening of the objects to which they are attached.

The *Watchman's Alarm* may be a rattle used by the police, or a systematic mode of communicating a signal of danger.

Funnel and *Barrel-filling Alarms* are to indicate that the vessel is nearly full.

A *Mill-hopper Alarm* is to indicate that the grist is about exhausted, and thus notify the miller that more grain is needed.

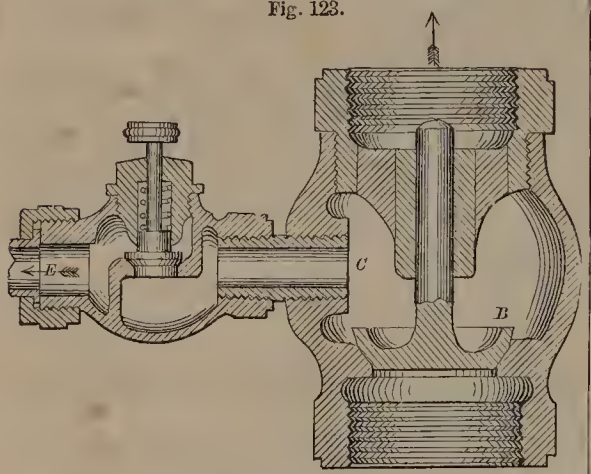
There are over two hundred patents in the United States for various forms of alarms.

See under the respective heads : —

Alarm check-valve.	Bank alarm-telegraph.
Alarm-clock.	Bilge-water alarm.
Alarm-funnel.	Burglar alarm.
Alarm-lock.	Clack.
Alarm-watch.	Clack-mill alarm.
Annunciator.	Clock alarm.
Atmospheric alarm-whistle.	Door alarm.

Earthquake alarm.
Electric alarm.
Electric annunciator.
Fire alarm.
Fire-damp alarm.
Fog alarm.
Gas alarm.
High-pressure alarm.
Iceberg alarm.
Leak alarm.
Low-water alarm.
Marine alarm.
Mill-hopper alarm.
Money-drawer alarm.
Nautical alarm.
Pocket alarm.
Safe alarm.
Shoal alarm.
Steam-boiler alarm.
Steam-whistle alarm.
Telegraphic alarm.
Temperature alarm.
Thermometric alarm.
Tide alarm.
Till alarm.
Trunk alarm.
Watch. Alarm
Watchman's alarm.

Fig. 123.



Alarm Check-Valve.

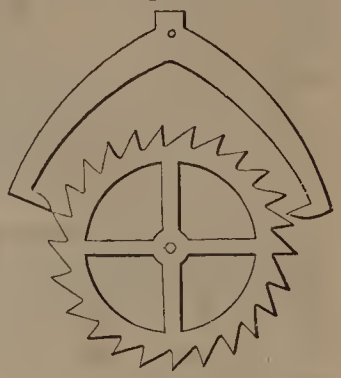
A-larm′ Check-valve. (SELLER'S IMPROVED.) (*Steam.*) A valve to notify the engineer whenever the injector ceases to operate or fails to start.

If the injector is not working into the boiler when the escape-valve is closed, the steam will back up in *C*, and tend to pass out into the water supply and tank. As soon, however, as any pressure occurs in the upper part of the supply-pipe, the check-valve *B* will close, and the steam then exerts its pressure on the small check in the lateral pipe *C E*, which leads to the waste-pipe. This small valve, which is kept in its seat by a spiral spring, as shown in the drawing, will then be raised, and allow the steam to escape into the waste-pipe in a way that cannot fail to secure notice.

A-larm′-clock. From a work published in 1661, we find that "Andrew Alciat of France had a kind of clock in his chamber that should awaken him at any hour of the night that he determined, and when it struck the determined hour, it struck fire likewise out of a flint, which fell among tinder, to light him a candle; it was the invention of one Caravagio of Sienna in Italy." The Marquis of Worcester, 1655, suggests that the tinder-box may form a serviceable pistol. This is anticipating some of the *burglar alarms* of our own time.

The clock alarm consists of a bell or wire coil and a hammer which is set in motion by an arrangement substantially similar to the recoil escapement in the attached cut. A weighted cord or spring, being wound on the axis of the scape-wheel, rotates it as soon as it is free to move. If we suppose a short hammer instead of a long pendulum attached to the axis of the pallets, and the wheel to be driven with sufficient force, it will oscillate the hammer and cause the head to strike on alternate sides of the bell inside which it vibrates.

Fig. 124.

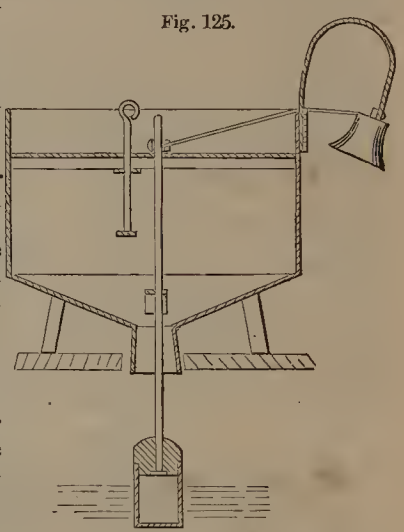


Recoil Escapement.

If the alarm were always to be let off at the same time it would only be necessary to set a pin in the proper place in the twelve-hour wheel to raise the lifting-piece which lets off the alarm at that time. To make it capable of adjustment, the discharging pin is set in another wheel (without teeth), which rides with a friction spring upon the socket of the twelve-hour wheel, and has a small movable dial attached to it, with figures so arranged in reference to the pin, that, whatever figure is made to come to a small pointer set as a tail to the hour-hand, the alarm shall be let off at that hour. The letting off does not require the same apparatus as the striking movement, because it is not to strike a definite number of blows, but to go till it is run down.

The lifting-piece is nothing but a lever with a stop or hook upon it, which, when it is dropped, takes hold of the alarm-wheel, and disengages it when raised.

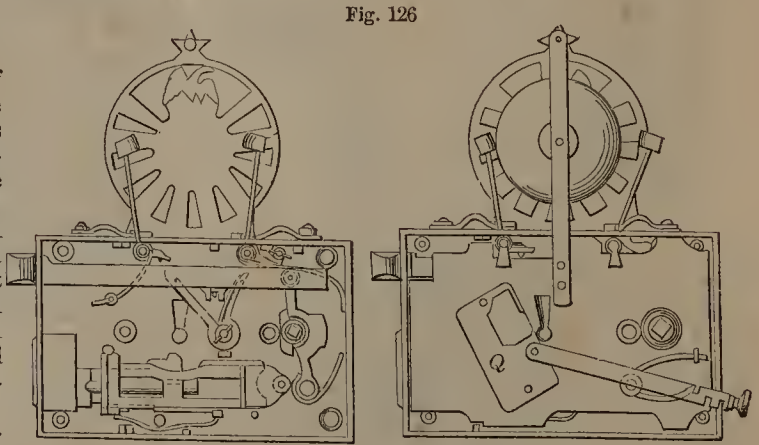
Fig. 125.



Alarm Funnel.

A-larm′-funnel. A funnel which indicates that liquid in the barrel has risen to a certain point. The funnel being placed over the bung-hole of the barrel, the rising liquid raises the float, which detaches the button from its stop and rings the alarm-bell.

Fig. 126



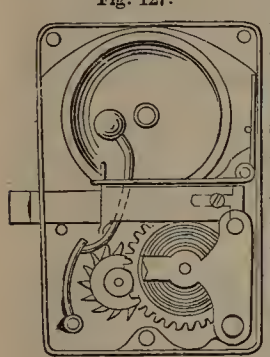
Euteneur's Lock-Alarm

A-larm'-lock. In the Marquis of Worcester's "Century of Inventions," No. 72, A.D. 1655, a lock is referred to which, if tampered with by a stranger, will start an alarm beyond the control of the intruder. As usual, the thing is merely hinted at, the purpose of that Digest of Inventions being more to act as a reminder to the inventor than as a specification for another reader.

EUTENEUR, September 19, 1865, (Fig. 126,) has an arrangement of devices by means of which any movement of the latch-bolt causes two hammers to strike a bell. A plate covers the key-hole to prevent the admission of a key from the outside; the plate is held closed by a bar attached thereto and projecting through the case. The two hammers are so pivoted as to be tripped by the motion of the latch-bolt, striking the bell on the recoil.

DECROW, December 12, 1865. The device consists of a bell, hammer, escapement, and a spring. The bolt is so arranged as to trip the escape-wheel, when moved in either a vertical or a horizontal direction, and release the hammer, which is oscillated rapidly to give a quick succession of strokes upon the bell.

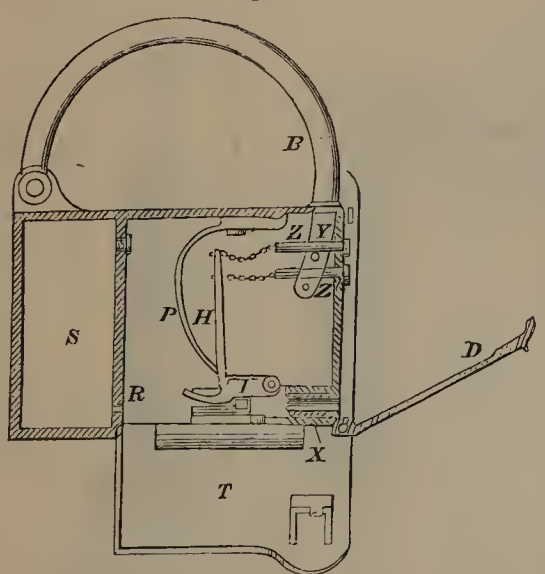
Fig. 127.



Decrow's Alarm.

A padlock with an alarm attachment is shown in Fig. 128. The shackle *B* is fastened by screws *Z Z*, whose heads are exposed. They are connected by chains to the arm *H* of a trigger *I*. The barrel *X* is moved by the spring *P*, a cap is exploded, a ball projected, and fire communicated through the opening *R* into the magazine *S*. *D* is a cover for the screw-heads *Z*. *T* is the fallen face-plate of the lock-case.

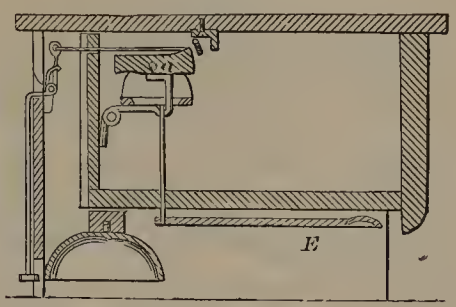
Fig. 128.



Andrew's Alarm-Lock.

A-larm'-lock for Tills. Alarm-locks are attached to tills so as to ring when the drawer is pulled open. The devices are numerous. In Fig. 129 is shown one in which the contact of the head *a* with a detent beneath the counter causes the said head to vibrate and swing the hammer-rod which

Fig. 129.



Tucker's Alarm-Till.

sounds the gong. By raising the trigger *E* the drawer may be opened silently.

A-larm'-watch. An instrument, not necessarily a timepiece, with going works, and adapted to run down and sound an alarm after a specific interval of time. See WATCH ALARM.

Al-ba'ta. German silver, composed of nickel, copper, and zinc; with the addition of small quantities of lead or iron in some formulas.

It is a white alloy, used for table-ware, etc., and resembles the Chinese Packfong, or white copper.

The following are some of the formulas:—

Common, Nickel, 4;	Copper, 20;	Zinc, 16.		
Better, " 6;	" 20;	" 10.		
For rolling, " 25;	" 20;	" 60.		
For casting, " 20;	" 20;	" 60;	Lead, 20.	
Packfong, " 31.6;	" 40.4;	" 25.4;	Iron, 2.6.	

See ALLOY.

Al'ber-type. (*Photogr.*) The process is as follows: "A plate of glass is covered with a solution of albumen, gelatine, and bichromate of potash, dried and exposed to light until hardened. It is then again covered with a solution of gelatine and bichromate of potash, and when dry exposed under the negative, and the film is then found to possess qualities analogous to a drawing made with fatty ink upon lithograph stone. All those portions of the film that were acted upon by the light will refuse water and take printing-ink, while those portions which were protected from light by the negative will take water and refuse ink. The ink and water will be absorbed by the film just in accordance with the gradations of light and shade in the negative. To produce a picture, wet the surface of the film, then apply ink, lay on paper, and pass through a press; the operation being substantially the same as lithography. The process is said to be rapid, and excellent pictures of all sizes may be printed in admirable style."—*Photographic News.*

Al'bo-lite Cem'ent. Invented by Riemann. Mix calcined and finely pulverized magnesite (native carbonate of magnesia) with infusorial earth, and stir in chloride of magnesium. Among the properties of the cement, as enumerated by the inventor, are a high degree of plasticity, and of hardness after it has become fixed, and a spontaneous development of heat as soon as it is solidified to the consistency of wax, this increasing in proportion to the size of the mass into which it has been molded. It is extremely hard, a peculiarity increased by its elasticity, and adheres very well to stone, wood, and dry oiled surfaces, but cannot be used under water. It is now largely employed in the preparation of ornamental moldings, for which, however, in consequence of the above-mentioned development of heat, gelatine molds must be cautiously used. By coating ornaments of gypsum with this cement it imparts to them a great degree

of hardness. It is also used for repairing worn-down sandstone steps, for facing stone and wooden steps, for fire-proof coating to boards in the interior of houses, and also for preserving railroad-ties, etc.

Al'bum. A book arranged to hold photographs, autographs, or memorial addresses of a private character.

The principal concern of the mechanic arts with the album is with devices for sewing the leaves in the book, making the slip-pockets for the reception of cards, clasps, and securing devices for the leaves of the cover.

The *album* was originally the tablet on which the Roman prætor's edict was written. It was *white*, and hung up as a bulletin-board in a public place.

It is now a book of friendly memorials: signatures, prose or poetic effusions, or photographs. It dates back to the church blank-book, or *white*-page book, in which were inscribed the names of benefactors of the church, in order that the appointed prayers might be made as the feast-days of their chosen saints recurred.

The Venerable Bede, in his preface to the Life of St. Cuthbert, A. D. 721, speaks of the record of the saint's name in the *album* at Lindisfarne. The name frequently occurs in ecclesiastical and other writings.

Al'bu-men Process in Photography. This process antedated the collodion, which is much more sensitive. It was invented by Niepce de St. Martin. The glass receives a coating from a solution of albumen to which bromide and iodide of potassium and a drop of caustic potash have been added, and after drying is exposed to the fumes of iodine. It is then silvered in a bath of nitro-acetate of silver, and dried. After passing again over the vapor of iodine it is ready for the camera. The image is developed by a solution of gallic acid, and fixed by a solution of hyposulphite of soda. — *Mayall.*

Al'car-ra'za. A vessel of porous earthenware used for cooling the contained liquids by evaporation from the exterior surface. See ICE-MACHINE. The word is Arabic, and the device was introduced into Europe by the Spanish Saracens.

Alcarrazas are made of a sandy marl made up into paste with saline water and lightly fired.

"In niches where the current of air could be artificially directed hung dripping alcarrazas."— *Description of the Alhambra.*

Al'co-hol En'gine. An engine in which the vapor of alcohol is used as a motive-power.

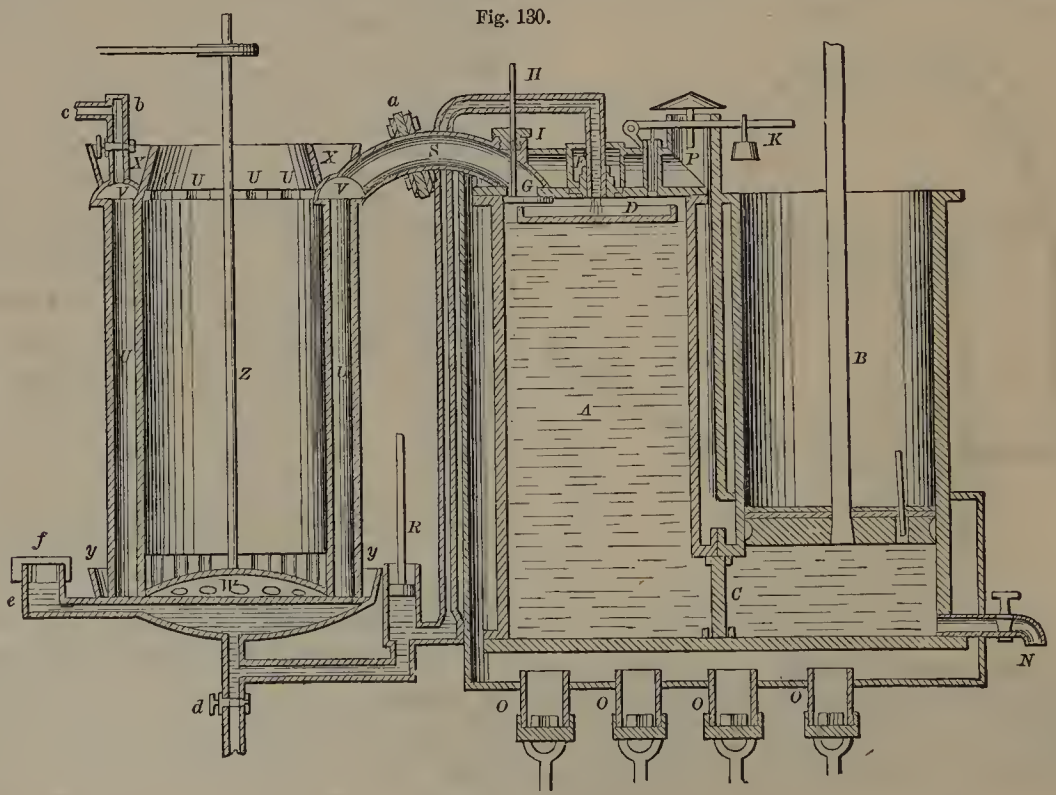
The first suggestion of the machine was by Rev. Edmund Cartwright at the latter end of the last century. The reason why the elastic vapor of alcohol was supposed to be preferable to that produced from water is that it boils at a temperature considerably below that of water. It must be recollected, however, that all leakage and escape of alcohol is not alone an absolute loss of a valuable material, but that such leakage is very dangerous, owing to the inflammability of the material.

HOWARD'S alcohol engine, English patent, 1825, was in use at the Rotherhithe Iron-Works for some time, but appears to have wearied out the patience or means of the inventor, no engine of that description being now usefully employed so far as we are aware. The engine referred to was intended to work up to 24 horse-power.

The engine had two vertical cylinders *A B*, of equal capacity, connected by a pipe *C*, at the lower part of each. A quantity of mercury or oil, which will not vaporize at the heat to be applied, is placed in each cylinder, so as to fill the base of one and nearly the whole of the other.

Within the cylinder *B* is a piston, exposed above to the pressure of the atmosphere, and packed in the cylinder in the usual manner. In the other cylinder *A* is a thin metallic dish *D*, floating freely upon the surface of the oil. A tube *E*, terminating in a nozzle pierced with small holes, passes through a stuffing-box in the cover of the cylinder *A*, in which also is a flap-valve *G* opened by a rod *H* as

Fig. 130.



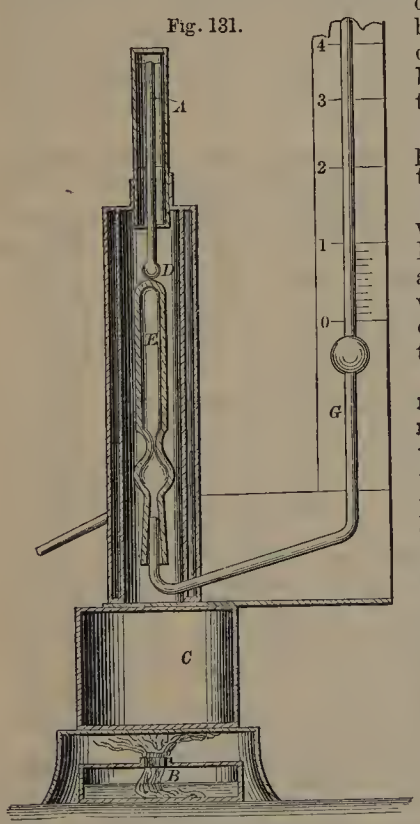
Howard's Alcohol Engine.

occasion requires. The valve is otherwise kept to its seat by a spring. *I* is the stuffing-box of the valve-rod; *K* the safety-valve. The piston has a plug by which a certain quantity of the fluid is admitted above its upper surface, there to remain. *N* is a discharge-cock. *o o* are argand-burners, which heat the cylinders *A B* by direct action upon their lower surfaces, the hot-air flue extending around them and terminating in the chimney *P*, which has a register-cap *a* by which the draft is regulated.

By means of a force-pump *R*, worked by the engine, a small quantity of alcohol is drawn from the condenser and injected through the pipe *E* into the dish *D*, which floats upon the hot oil in the cylinder *A*, and is thereby flashed into steam. The expansion of the alcohol depresses the column of oil in the cylinder *A*, driving it through the passage *C* into the cylinder *B*, where it raises the piston.

When the piston has attained its highest elevation, the valve *G* is opened and the vapor escapes by pipe *S* to the condenser, which consists of an upper and lower chamber connected by pipes *V V*. These pipes are surrounded by flannel constantly wetted by water dripping from the trough *X*, and the evaporation is expedited by a continued draft of air from the rotating fly *Z*, which is driven by the engine. *Y* is the lower trough, which receives the superfluous water, and *W* is the bottom chamber, which contains the condensed vapor and from which it is drawn by pump *R* to produce each upward movement of the piston. A cork or wooden packing in the connecting-pipe *S* prevents the conduction of heat from one part of the apparatus to the other. The condensation of the alcoholic vapor causes the return of the oil into the cylinder *A*, and the atmospheric pressure causes the piston to descend. *c*, *b*, are the pipe and stop-cock by which the atmospheric contents of the condenser are withdrawn, previous to starting the engine. *d* is the discharge-pipe by which the condenser may be drawn from the chamber *W*. *f* is the pipe at which the chamber *W* is charged with alcohol. It is closed by a screw-pipe when the machine is in action.

Fig. 131.



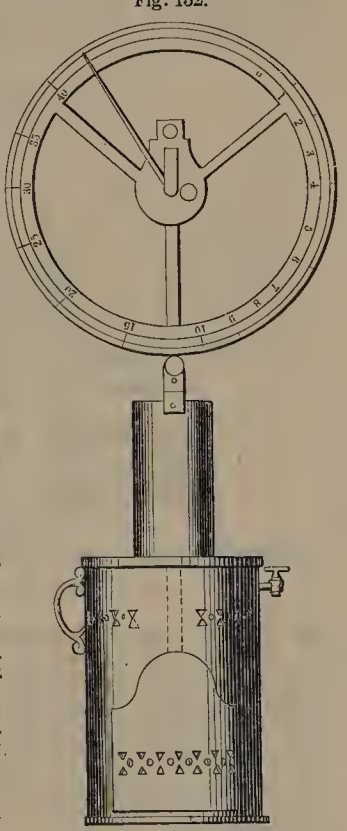
Guth's Alcoholmeter.

Al'co-hol'-me-ter. A modification of the hydrometer, for the purpose of ascertaining the comparative specific gravity and consequent amount of alcohol in spirituous liquors, etc. This instrument may either be so constructed as to be sunk, by weights, to a uniform depth in the liquor tested, or it may indicate the gravity by the amount of its submergence, as shown on a graduated stem, taking either pure alcohol or "proof" as a standard; the latter mode of construction is more convenient in practice, and more generally adopted. The absolute percentage of alcohol, or the degree above or below proof, is deduced from tables constructed for that purpose and corresponding to various temperatures of the liquid.

Guth, June 28, 1859. In this alcoholmeter the evaporation of a fixed quantity of alcoholic fluid is made to exhibit the exact percentage of alcohol contained in the said liquid. While the tube *E* is yet detached from the apparatus, it is partially filled with mercury, and then receives a definite amount of the alcoholic liquid to be tested. When inverted and placed in position in the instrument the liquid and mercury change places, the former occupying the upper part of chamber *E*. Heat being applied, by means of the spirit-lamp *B*, to the water in chamber *C*, the vapor rising therefrom, filling chamber *D*, heats the mercury and the alcoholic liquid, the temperature being indicated by the thermometer *A*. As alcoholic vapor is eliminated from the liquid it presses upon the column of mercury, causing it to rise in the stem *G*, and the height of the column against the graduated scale indicates the amount of spirit.

The ebullition alcoholmeter of Vidal is founded upon his discovery that the boiling temperature of alcoholic liquors is proportional to the quantity of alcohol contained in them. It consists of a spirit-lamp, beneath a small boiler, into which a large cylindrical glass bulb is plunged, having an upright stem of such caliber that the quicksilver contained in them may, by its expansion and ascent when heated, raise before it a little glass float in the stem, which is connected by a thread with a similar glass bead that hangs in the air. The thread passes round a pulley, which, turning with the motion of the beads, causes the index to move along the graduated circular scale.

Fig. 132.



Ebullition Alcoholmeter.

The numbers on this scale represent percentages of absolute alcohol; so the number opposite to which the index stops, when the liquor in the cylinder over the lamp boils briskly, denotes the percentage of alcohol in it.

Siemen's alcoholmeter, Berlin, 1869, is thus described: "As the spirit — no matter of what strength — leaves the still, it passes into a cylindrical vessel, and from this, through a drum something like that of an ordinary gas-meter, into the

cask which is to contain it. On its way through the apparatus it is measured, gaged, and registered with the greatest possible exactness. First, its bulk or volume is measured and indicated in gallons and decimal parts; and, second, the quantity of either absolute alcohol or of proof-spirit which it contains is measured and indicated independently. The measurement and registration of the total bulk or quantity of spirit which passes over is obviously done directly by the rotation of the drum, each of the three divisions of which holds exactly five gallons. The indication of the strength of the spirit is done by a swimmer in the cylindrical vessel into which the alcohol first enters as it leaves the still. This swimmer is attached to a pointer, which, in being elevated and depressed by the lowering or rising of the swimmer, according to the varying specific gravity of the liquid, limits the reciprocating movements of a graduated tongue in connection with the counter-work. Thus, not only do the distiller and the exciseman know at a glance how much spirit in total has been distilled within a given time, but likewise how much proof-spirit it is equivalent to. —*Engineer.*

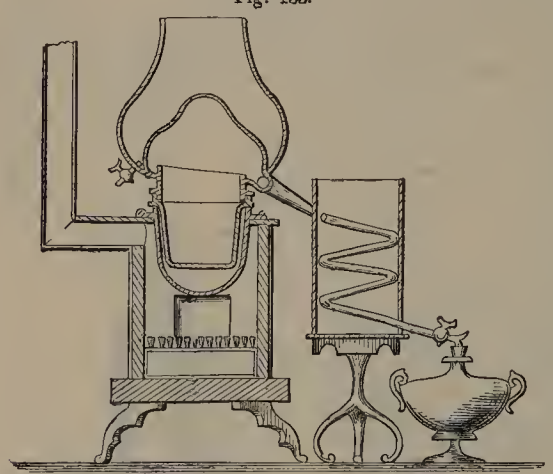
See also LIQUID-METER.

Al'cove. (*Architecture.*) A recess separated from a main chamber by columns, antæ, and balusters.

A recess in a room for a bed or for seats.

A-lem'bic. The head or cap which is placed upon the cucurbit, and which discharges by its beak into the receiver. The cucurbit contains the liquid to be distilled, and the alembic is luted thereto to

Fig. 133.



Alembic.

prevent the escape of vapor which is raised by the heat of the fire, and is conducted to the receiver to be condensed. Some alembics have an aperture in the head to admit material to the retort when the stopper is temporarily removed.

We are indebted to the Arabs for this apparatus and its name. Zozimus, who flourished about A. D. 400, described the operation of purifying water by distillation.

Djafar, the great Arabian chemist, about A. D. 875 discovered nitric acid, which he obtained by the distillation in a retort of Cyprus vitriol, alum, and saltpeter. He obtained aqua-regia by the addition of sal-ammoniac, and no doubt felt that in obtaining a solvent of gold he had discovered the long-desired *aurum potabile.*

Rhazes, the Arabian, born 860, obtained absolute alcohol by distilling spirits of wine with quicklime.

Achild Bechil, of the same people, distilled together an extract of urine, clay, lime, and powdered charcoal, and obtained phosphorus.

A *blind-alembic* is one having a capital with no rostrum.

A-len'çon Lace. Also called *blonde.* A variety of lace formed of two threads, twisted and worked to a hexagonal mesh.

Alençon point is formed of two threads to a pillar, with octagonal and square meshes alternately.

Al'eu-rom'e-ter. The name given to an instrument invented about 1849, by M. Boland, a Parisian baker, for determining the quality of the gluten in different specimens of wheaten flour, and their consequent adaptation for bread-making. A tube of about six inches in length is divided into two parts, of which the smaller one, about two inches in length and holding a given amount of gluten, is screwed on to the longer tube, which is fitted with a piston having a graduated stem. The apparatus is then exposed to a moderate degree of heat, when the gluten expands, forcing up the piston, the amount of expansion being indicated by the distance the stem protrudes from the tube. It was found that gluten obtained from flour of good quality would expand to four or five times its original bulk, and had the smell of warm bread, while that of bad flour became viscid, with a tendency to adhere to the tube, and in some instances emitting an unpleasant odor.

Al'i-dade. (*Optical Instr.*) The movable arm of a graduated instrument carrying sights or a telescope, by which an angle is measured from a base line observed through the stationary or level line of sights.

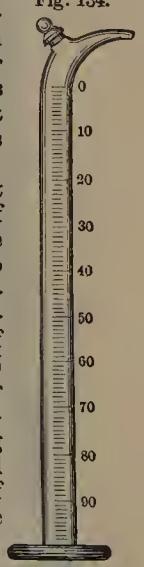
Used in theodolites, astrolabes, demicircles, and numerous other angulometers.

A-lign'ment. (*Engineering.*) The ground plan of a road or earthwork.

Al'ka-lim'e-ter. The object of this instrument is to ascertain the value of the alkalies of commerce. It was invented by Dr. Ure, about 1816, or by Mr. Descroizelles, and consists essentially of a graduated tube closed at one end, each graduation corresponding to a sufficient quantity of sulphuric or other acid to neutralize a given amount of pure soda or potash dissolved in water. The strength of the alkali is inferred from the amount of acid required to neutralize it.

The instrument recommended by Dr. Faraday consists of a burette supported upon a foot and graduated into one hundred equal parts, the space between each two of the divisions being capable of containing ten grains of distilled water. The upper part of the instrument is shaped, as shown in the figure, for the convenient introduction of the test acid and its subsequent delivery in drops.

Fig. 134.



Alkalimeter.

To employ it for estimating the amount of carbonate of potash in any sample of pearlash, weigh out 100 grains of the ash, dissolve them in boiling water, so that, when cool, the mixture has a specific gravity of 1.1268. Filter if necessary, and tinge blue with infusion of litmus; then fill the alkalimeter to 65 with the test acid, diluting with water to 0°, and add the diluted acid gradually and cautiously until the reddening effect is produced upon the dissolved sample. The number of measures of acid required represents the percentage of carbonate of potash in the sample.

To estimate the amount of potash contained in the sample, either as caustic potash or carbonate of potash, fill the alkalimeter to

49 with the test acid, the 100 measures being again made up with water. The number of divisions of this dilute acid required to neutralize 100 grains of the sample will correspond to the proportion of pure potash in the sample.

For the determination of carbonate of soda, the alkalimeter must be filled to 54.6 with the test acid, which must then be used as before. For the estimation of caustic soda, the operator will require to fill the instrument to 23.4. The number of measures required to change the blue of the solution to red will in both cases correspond to the percentages of caustic or carbonated alkali required.

All-a-long'. A bookbinder's term to denote that the sewing-thread passes from end to end of the fold, or directly between the distant points of puncturation.

Al'lege. (*Fr.*) A ballast-boat.

Al-lette'. (*Architecture.*) A wing of a building; a buttress or pilaster.

Al'ley. (*Printing.*) The compositor's standing-place between two opposite frames.

Al-loy'. An alloy is a combination by fusion of two or more metals, as brass and zinc, tin and lead, silver and copper, etc.

Many alloys are composed of definite chemical proportions of their component metals, whilst in others the metals unite in any proportions.

The best-known and perhaps the most generally useful alloy is brass, which is formed by the fusion together of copper and zinc.

The Colossus at Rhodes was said to have been constructed of brass B. C. 288. Bronze is a much more ancient alloy than brass, and has been known from a very remote antiquity. See BRASS and BRONZE. All alloys are opaque, have a metallic luster, are more or less elastic, ductile, and malleable, and are good conductors of heat and electricity. Those consisting of metals of very different degrees of fusibility are usually malleable when cold and brittle when hot. Metallic compounds containing mercury are *amalgams*. Metals do not unite indifferently with each other, but have certain affinities; thus silver, which will hardly unite with iron, combines readily with gold, copper, or lead. Alloys are generally harder and less ductile than the mean of their constituents, and their specific gravity is usually either greater or less than this mean. (See Table.) The melting-point of alloys is usually below that of either of the simple metals composing them; thus, an alloy of 8 parts bismuth, 5 lead, and 3 tin, fuses at the heat of boiling water, or 212°. See FUSIBLE ALLOYS.

They very frequently possess more tenacity than their constituents would seem to indicate; thus an alloy of 12 parts lead and 1 part zinc has double the tenacity of the latter metal, or about six times that of lead.

They are, in general, more easily oxidized than their component metals. An alloy of tin and lead unites with oxygen so readily as to take fire and burn when heated to redness.

A very slight modification of the components often produces a great change in the mechanical properties; brass, containing two or three per cent of lead, is most readily turned, but works badly under the hammer, while that of the best quality for hammering is not turned with facility, owing to its toughness.

The precious metals, when employed for coin or jewelry, are invariably alloyed to increase their hardness; the degree of fineness, or proportion of pure metal, being usually estimated in carats or twenty-fourths. In this case the term "alloy" is often understood to apply merely to the baser metal with which the gold or silver is combined. Thus the British standard for gold is 22 parts pure gold and 2 parts alloy, or 22 carats fine; for silver, 222 parts pure silver and 18 parts alloy.

The alloy for gold is an indefinite proportion of silver and copper; that for silver is always copper. The standard for silver plate is the same as for coin; that for jeweler's gold is 18 carats, but for some purposes the fineness is reduced to 12 and even 9 carats; silver is used for the alloy, and copper may be added to heighten the color.

Silver and palladium unite in any proportions, and it has been found that this alloy is not so readily tarnished as silver; it has been used for the graduated scales of mathematical instruments. Platinum has been used with silver for similar purposes, but requires greater care in fusion to make the combination.

Steel is much improved for cutlery by being alloyed with about $\frac{1}{100}$ part of silver; it is also improved by $\frac{1}{500}$ part of platinum.

From one to two per cent of rhodium has also been combined with steel, with excellent results.

BRASSES AND BRONZES WITH THE ADDITION OF IRON.

	Copper.	Tin.	Zinc.	Iron.	Lead.	Nickel.	Silver.
Ancient Bronze Sword, Ireland	83.50	5 15		3.0	8.35		
Ancient Bronze Sword, Thames, England	89.69	9.58		0.33			
Ancient Bronze Axe-head, Ireland	89.33	9.19		0.33			
Ancient Bronze Wedge, Ireland	94.	5.9		0.1			
Ancient Bronze Knife, Amaro, South America	95.66	3.96		0.37			
Coin of Hadrian	85.67	1.14	10.85	.74	1.73		
" " Tacitus	91.46			2.31			
" " Probus	90.68	2.00	1.39	.61	2.33		2.29
" " "	94.65	.45		.80	.45		3 22
" " Pompey	74.17	8.47		.29	16.65		
Chinese White Copper (Packfong)	40.4		25.4	2.6		31.6	
Keirs Metal, English Patent, Dec. 10, 1779	100.		75.	10.			Glass.
Keirs Metal, English Patent (another formula)	100.		80.	10.			40.
Tractable Yellow Metal (old formula)	55.33		41.8	4.06			
Fontainemoreau's English Patent, 1838	8.		90.	1.			
Cutler's English Patent, 1838	16.		5.	3.		.5	
Sorel's White Brass, 1840	10.		80.	10.			
Parke's English Patent, 1844	91.		21.	45.5		45.5	
Parke's English Patent (another formula)	4.5	128.	67.	2.5			
Parke's English Patent (another formula)	3.	48.	50.	1.			
Stirling's Gun-Metal, English Patent, 1846	50.		25.	1-8			Man
Stirling's "British Gold," English Patent, 1846	400.		93.	7.			6.
Bell-Metal (Overman)	71.	26.	2.	1.			
Aich's Metal, English Patent, Feb. 3, 1860	60.		38.12.5	1.5			
Rosthorn's Gun-Metal, Austria, 1861	55.04	0 83	42.36	1.77			
Rosthorn's Gun-Metal (another analysis)	57.63	0.15	40 22	1.86			
Navy Brass, Austria	60.		38.12	1.8			
Parisian Clock Bells	72.	26.5		1.5			
Birkholz Metal, United States Patent, Mar. 11, 1862	60.		38.	2.			

An English work of 1853 cites the addition of one to two per cent of iron to brass to give strength and sonorousness; and further states that "large guns, large screws, propeller-vanes, mill-brasses, railway-bearings, bells, and other articles are made of a metal in which copper, zinc, tin, and iron, all take part."

(*Brass.*) The alloys of copper and zinc retain their malleability and ductility when the zinc is not above thirty-three to forty per cent of the alloy. When the zinc is in excess of this a crystalline character begins to prevail. An alloy of 1 copper, 2 zinc, may be crumbled in a mortar when cold.

Yellow brass, that files and turns well, may consist of copper 32, zinc 9 to 18. A greater proportion of zinc makes it harder and less tractable; with less zinc, it is more tenacious and hangs to the file like copper.

Yellow brass (copper 2, zinc 1) is hardened by the addition of two to three per cent of tin, or made more malleable by the same proportion of lead. The tin whitens it; the lead reddens it. See BRASS.

(*Bronze.*) A compound of copper and tin. The addition of tin increases the fusibility of copper. The red color is not materially affected by the addition of 5 parts tin to 32 copper, which makes engineer's brasses; it is considerably whitened when 32 copper is alloyed with 12 tin, this being the limit of bell-metal; and is quite white when 32 copper, 16 tin, is reached, this being speculum metal. When it has ceased to serve for producing sound it is used for reflecting light.

A small addition of zinc to a bronze alloy assists in the mixing, and increases the malleability without materially affecting the hardness. Lead increases the ductility of gun-metal, at the expense of its hardness and color. Mr. Donkin proposes the addition of nickel. Dr. Ure suggests antimony. The addition of from two to four per cent of iron to the gun-metal is claimed to make an extremely tough alloy. See GUN-METAL; BRONZE.

Sir J. Gardiner Wilkinson mentions finding a bronze chisel among the chippings of the limestone rocks in the neighborhood of Thebes, where it had been accidentally left by the workmen in ancient times. It is 9¼ inches in length, diameter at the summit 1 inch, and weighs 1 lb. 12 oz.

FUSIBLE ALLOYS (*Composition of*).

	Type-metal.	Lead.	Tin.	Bismuth.	Cadmium.	Melting-point.
Rose's		1	1	2		201° F.
Newton's		5	3	8		212
Newton's (another formula)		3	2	5		199
French	1	5	4	8		
Wood's			1	3	1	210
Wood's		6		7	1	180
Wood's Patent (March 20, 1860)		4	2	7-8	1-2	150-160
Wood's Patent for filling teeth (Sept. 4, 1864)		1-2	2-3	3-4	1-2	

KUPFFER'S TABLE OF FUSIBLE ALLOYS, — ATOMIC PROPORTIONS.

Lead.	Tin.	Melting-point.
1	5	381° F.
1	4	372
1	3	367
1	2	385
1	1	466
3	1	552

Holtzapffel's list is as follows: —

Tin.	Lead.	Bismuth.	Mercury.	Melting-point.
1	25	...	...	558° F.
1	10	...	...	541
1	5	...	...	511
1	3	...	...	482
1	2	...	..	441
1	1	...	...	370
1½	1	..	...	334
2	1	...	...	340
3	1	...	...	356
4	1	...	...	365
5	1	...	...	378
6	1	...	...	381
4	4	1	...	320
3	3	1	...	310
2	2	1	...	292
1	1	1	...	254
1	2	2	...	236
5	3	3	...	202
5	3	3	3	122

According to a table arranged by Professor P. H. Vander Weyde, the fusion points of the undermentioned alloys are as follows: —

Bismuth.	Tin.	Lead.	Mercury.	Melting-point.
5	2	3	1	167° F.
4	...	1	⅓	185
4	1	1	...	203
5	4	1	...	257
1	...	1	...	284
...	3	2	...	329
...	3	1	...	338
Pure tin				428
Pure bismuth				500
Pure lead				617

A more extended table of the fusible points of the ordinary triple alloys is given in the *Bulletin de la Société Chimique*: —

Lead.	Tin.	Bismuth.	Point of Fusion.	Point of Solidification.
120	140	120	130° C.	112° C.
145	145	100	140	129
150	150	75	150	135
150	150	50	160	150
170	180	35	170	163
210	190	30	180	165
140	155	30	190	180
200	185	30	200	180
200	180	30	210	180
240	150	30	220	180
207	194	30	180	180

The Egyptians soldered with lead as long ago as the time of Thothmes, B. C. 1490, the time of Moses. Pliny refers to the art, and says it requires the addition of tin for use as a solder. The tin came mainly from the Cassiterides (Cornwall).

GOLD ALLOYS.

	Gold.	Silver.	Copper.
18-carat gold of yellow tint	360	66	54
18-carat gold of red tint	360	42	78
16-carat gold	36	6	12
16-carat gold nearly (yellow tint)	20	7	5
16-carat gold nearly (red tint)	20	2	8
11-carat gold nearly	20	11	11

Gold solders are made from gold of the quality of the article, say 18 or 16 carats, to which is added

$\frac{1}{12}$ of silver and one $\frac{1}{24}$ of copper; or a larger proportion of silver and copper for ware of inferior fineness.

JEWELER'S ALLOYS.

	Brass.	Copper.	Tin.	Zinc.	Silver.	Platinum.	Arsenic.	Antimony.	Glass.
Blanched Copper (Mock Silver)		16					1		
Imitation Gold (Hermstadt's); (this resembles gold in color and specific gravity)		7		1		16			
Semilor		5		1					
Manheim Gold		4		1	}				
or		3	$\frac{1}{4}$	1	}				
Mosaic Gold (Hamilton and Parker's Patent)		32		33					
Pinchbeck		5		2					
Mock Platinum	8			5					
Bath Metal	32			9					
Very hard Bronze (Chantrey's)		32	5	5					
Speculum Metal		7	4	3					
" "		6	2				1		
" "			1					1	
Martin's Patent, Aug. 23, 1859		100		18$\frac{3}{4}$	16				$\frac{10}{16}$
Or Molu		48		52					
Tombac (Malay, tambaga, copper)		16	1	1					
Red Tombac		11		1					
Mock Silver (Toucas's Patent, 1856, England)		5	1	1	1 Lead.	4 Nickel.		1	

Mock Gold (Hackert's, patented June 11, 1867), cream of tartar, 8 oz.; saltpeter, 1 oz.; melt, and add melted copper, 8 oz.; borax, 1 oz.; zinc, 1 oz.; tutty, 1 oz.

SOLDERS (*Composition of*).

	Gold.	Silver.	Copper.	Tin.	Zinc.	Lead.	Bismuth.	Brass.	Melting-point.
Pewterer's				2		1			360°
Pewterer's, soft				3		4	2		
" "				2		1	1		
Tinman's				1		1			393
Coarse				1		3			500
Plumbers'				1		2			475
Hard Spelter			16		12				1869
Gold *	12	2	4						
For Brazing Steel		19	1					2	
Hardest Silver		4	1						
Hard Silver		3						1	
Soft Silver		2						1	
For Aluminium (Starr's, Mar. 10, 1868)		2		2	1	2			

* Various proportions are employed, according to the fineness of the article, so as not to risk the test of assay.

TYPE-METAL (*Composition of*).

	Lead.	Antimony.	Tin.	Nickel.	Cobalt.	Copper.	Bismuth.	Cadmium.
For the smallest and most brittle types	3	1						
For those a grade softer	4	1						
" medium sized types	5	1						
" large types	6	1						
" largest and softest types	7	1						
" stereotype plates	4-8	1						
" " " new recipe	500		300					225
Besley's patent type-metal (1855, England)	100	30	20	8	5	8	2	

From four to six per cent of tin is used in the smaller types, and sometimes a small amount of copper.

In this alloy the antimony fulfils another service besides imparting hardness. Antimony expands somewhat in cooling, whereas lead contracts considerably; the antimony therefore, within certain limits, compensates for the contraction, causing the alloy to retain the full size of the mold, making the letters sharp.

Sometimes, from motives of economy, the neighboring parts of machinery are not wrought accurately to correspond one with the other, but metal is poured in to fill up the intermediate space and make contact. Antimony is an essential addition in such cases to prevent the contraction the lead alone would sustain, and which would defeat the intended object, as the metal would otherwise become smaller than the space to be filled.

WHITE METAL ALLOYS.

	Copper.	Tin.	Zinc.	Lead.	Antimony.	Arsenic.	Bismuth.	Nickel.	Brass.
Speculum Metal		1			1				
" "	6	2				1			
" "	7	4	3						
Pewter	6	112	2	16					
"		4		1					
Hard Pewter	4	192			16				
Best Pewter		100			17				
Pewterer's "Temper"	1	2							
Pot Metal (used also for faucets)	10			6-8		1			
Shot Metal				56					
Cowper's alloy for turning in the *rose engine* for subsequent printing as letterpress		2					1		
Biddery Ware	16	2	128	4					
Britannia Metal	1	1			2				
Britannia Metal (another formula)		4			4		4		4
Britannia Metal (Lardner's)	8	392			28				8
Britannia Metal (Overman)	3	88	1		7	Steel.			
German Tutania	1	43			4				
Spanish "		24			2	1			
Queen's Metal		9		1	1		1		
Queen's Metal (another formula)	4	100			8		1		Cadmium.
Parisian White Metal	69.8		5.5					19.8	4.7
Common Albata or German Silver	20		16					3-4	
Best Albata or German Silver	20		8-10			Iron.		5-6	
White Copper or Tutenag	50		31					19	
Packfong (Chinese)	40.4		25.4			2.6		31.6	
Packfong (more malleable)	5		7					7	
Packfong	53.39		13					17.48	
German Silver (finest quality)	1		2					1	
German Silver (for rolling)	20		60					25	
German Silver (for casting)	20		60	20				20	
German Silver (original formula)	25		40			3		32	
German White Copper	88	Silex Trace	Clay Trace		Trace	Trace		8.75	

SPECIAL FORMULAS.

A metal that expands in cooling; useful in filling defects in iron castings: —

Lead	9
Antimony	2
Bismuth	1

BABBITT metal: —

Copper	1
Regulus of Antimony	1
Tin	10

Melt the copper first, then the antimony, then the tin, strewing charcoal-powder over the crucible to

prevent it from burning away. Cast it in bars. It should not be kept hot on the fire any longer than is absolutely essential. Wash the box to be tinned with alcohol, and then sprinkle powdered sal-ammoniac on it; hold it over the fire until the same fuses, then plunge it in melted tin. All parts not to be tinned must be washed with clay. Muriate of zinc, that is, zinc cut with muriatic acid, may be employed instead of the ammoniac, where it can be obtained. When the box is tinned it will take the Babbitt, but it must be pretty hot before the Babbitt is poured in.

Babbitt's English Patent gives the proportions: —

Tin	50
Antimony	5
Copper	1

Birkholz's metal: —

Cast-iron	2 lbs.
Charcoal	2 oz.

are heated in a crucible to a white heat; add thereto

Copper	60 lbs.

Heat till both are melted together, then add

Borax	4 oz.
Zinc	38 lbs.

making 100 pounds of the composition.

These are the materials and almost exactly the proportions of the Austrian Navy gun-metal. See Bronzes and Brasses with the Addition of Iron (p. 61).

Dinsman's metal for journal-boxes, patented February 27, 1866: —

Copper	1 lb.
Glass	4 oz.
Borax	1 oz.
Prussiate of Potash	½ oz.
Lead	8 oz.

In his patent of October 15, 1867, 1 oz. of tin is substituted for the 8 oz. of lead.

An alloy of

Silver	80
Platinum	20

resists the tarnishing action of sulphur.

Baron Wetterstedt's alloy for sheathing for ships: —

Lead	100
Antimony	3

Kennelly's patent, March 31, 1863. For horse-shoes: —

American Charcoal Iron	30 lbs.
Bone-dust	4 oz.
Manganese	2 "
Ferrocyanide of Potash	1 "
Hematite	1 "
Wolfram	7 "

melted and cast in molds of the required shape.

Alloy for organ-pipes: —

Lead	50
Tin	25

Burton's patent, February 12, 1867. For plow-shares: —

Copper	14
Tin	14
Zinc	77
Antimony	3
Lead	1

Johnston's patent, November 26, 1867. For dental uses: —

Sodium or potassium, or an amalgam of either, is added to mercury to facilitate its union with silver, tin, cadmium, platinum, etc.

Brander's patent, February 12, 1867. For roofing: —

Lead	75
Zinc	25

are made into an ingot, coated with pure tin, and rolled.

Brayton's patent, August 6, 1867. For eyelets: —

Tin	4
Zinc	1

Taylor's patent, January 8, 1867. For sabots of projectiles: —

Lead	4
Tin	1

for moderate charges. The tin is increased for heavier charges and projectiles to the extent of

Lead	120
Tin	78

With projectiles of 300 lbs. and over, 3 lbs. of copper are added to the alloy for a sabot.

Two new alloys of tin and lead are described in a recent French publication. While containing less tin than is used in common pewter, they are said to possess most of its advantages. They are not acted upon by vinegar, sour wine, or salt-water. The first is made by melting 1 part of tin with 2.4 parts of lead. The lead is first melted and skimmed, then the tin is added, and the mixture is stirred continually with a wooden stick until it begins to cool, to prevent the lead from settling to the bottom. This mixture has the density of 9.64, and its melting-point is 320° Fah. It may be rolled cold, and the plates do not crackle when bent. It takes a very good polish, and tarnishes but little on exposure. It will mark paper like lead, and is so soft that it may be scratched with the nail, but it will not foul a saw or file.

The second alloy is made by melting together in the same way 1 part of tin with 1.25 parts of lead. This alloy is less elastic and harder than the foregoing. It is rather brittle, less malleable than the former, and fills up a file. Neither of these alloys was acted on by boiling with acetic acid for half an hour, and standing in the acid for twenty-four hours longer, nor had salt-water any action upon them; hence they may be useful for some kinds of utensils.

VIGOUROUX'S ALLOY FOR BEER-TAPS.

	Tin.	Antimony.	Nickel.
For the body	785	195	20
" " key	807	175	18
Or	715	215	70

Cock-metal is an alloy of copper and of lead for faucets.

Metallic injection for anatomical preparations: —

Bismuth	1
Lead	1
Tin	1

with the addition of a small amount of mercury.

HACKERT's patent, May 17, 1864. For knobs and hardware :—

Copper	3
Arsenic	3
Cream of Tartar	2

PFEIFFER's patent, August 14, 1866 :—

Lead	98
Copper	1
Tin	¾
Antimony	⅛
Bismuth	⅛

HOOD's alloy for ship's bolts (England, 1844) :—

Copper	40.4
Zinc	3.8
Lead	16.5
Antimony	5.1

STRUBING's box metal for bearings (Engl., 1849) :—

Zinc	75
Tin	18
Lead	4½
Antimony	2½

(*Oreide.*) An analysis of this new compound by a German chemist gives the following :—

Copper	79.7
Zinc	13.5
Nickel	6.09
Iron	0.28
Tin	0.09

The two latter he regarded as mere accidental ingredients.

According to another formula oreide consists of

Pure Copper	100
Zinc or (preferably) Tin	17
Magnesia	6
Sal-ammoniac	3.6
Quicklime	1.8
Tartar of Commerce	9

See OREIDE.

An alloy for silver coin, etc., upon which experiments have been made in France, and which is said to render the metal more homogeneous than the common alloy of pure copper, less liable to be tarnished by sulphureted hydrogen, and which, when toughened by continued rolling, may be restored by simple heating, is as follows :—

Copper	93
Zinc	72
To be added to Silver	835

MAGEE's alloy for moldboards of plows. September 9, 1871.

Copper	85
Tin	12
Zinc	3

Aluminium bronze, consisting of copper 90, aluminium 10 per cent (by weight, we suppose), has been stated to have the strength of cast-steel ; a statement apparently confirmed by Mr. Anderson of the Royal Gun Factory in England, and by the experiments of Mr. Morin, Nanterre, where it was found that the tensile strength of this metal is of 5,328 kilogrammes to the square centimeter. At the same time a very important point was determined, — the transverse strength or resistance to being bent. This was found to be for brass, 2.22 ; gun-metal, 0.15 ; aluminium bronze, 0.05. That is to say, three equal bars of these different metals were fastened at one end so as to be perfectly horizontal, a certain equal weight was placed at the free end of each bar, and the result measured by an instrument for that purpose. Brass bent at 2.22 degrees of the instrument, the other metals as indicated above, thus showing the resistance of aluminium bronze to be 44 times greater than brass. The transverse strength, the resistance to permanent flexion, resistance to friction, and the superior resistance to oxidation displayed by this metal, although the latter quality has not yet been accurately determined, admirably qualify it for delicate mechanism and also for purposes where hardened steel was entirely employed. The tenacity of this alloy is astonishing, and is hardly equalled by any other metal ; it is more difficult to cut than gold or brass, but the cut is very clean and smooth.

The alloy of iridium and osmium, called *iridosmine*, is the hardest of all alloys, and is used for pointing the Hawkins "Everlasting Pen" (English).

Miclon, of Paris, proposes a new alloy for the manufacture of all metallic articles, — bells, hammers, anvils, rails, and non-cutting tools. The alloy consists of twenty parts of iron turnings or tin waste, eighty parts of steel, four parts of manganese, and four parts of borax ; but these proportions may be varied.

When it is desired to increase the tenacity of the alloy, two or three parts of wolfram are added. When the cupola is ready, the iron and steel are poured in, then the manganese and borax, and the vessel is filled up with coke.

A number of other alloys are known and used, including some of Eastern origin. The latter are generally of little practical importance. Such are—

Aurum Musivum, same as Mosaic gold.
Clinquant, same as yellow copper ; Dutch gold.
Caraeoly, composed of gold, silver, and copper.
Calin, a Chinese alloy composed of lead and tin.
Electrum, an ancient alloy of gold and silver.

The following table affords a ready means for the conversion of decimal proportion into divisions of the pound avoirdupois. The proportions of metals in formulas for alloys are sometimes stated in one way and sometimes in the other.

Dec. of lb.	Oz.	dr.	Dec. of lb.	Oz.	dr.	Dec. of lb.	Oz.	dr.	Dec. of lb.	Oz.	dr.
.0039		1	.1289	2	1	.2539	4	1	.3789	6	1
.0078		2	.1328	2	2	.2578	4	2	.3828	6	2
.0117		3	.1367	2	3	.2617	4	3	.3867	6	3
.0156		4	.1406	2	4	.2656	4	4	.3906	6	4
.0195		5	.1445	2	5	.2695	4	5	.3945	6	5
.0234		6	.1484	2	6	.2734	4	6	.3984	6	6
.0273		7	.1523	2	7	.2773	4	7	.4023	6	7
.0313		8	.1562	2	8	.2813	4	8	.4062	6	8
.0352		9	.1601	2	9	.2852	4	9	.4102	6	9
.0391		10	.1641	2	10	.2891	4	10	.4141	6	10
.0430		11	.1680	2	11	.2930	4	11	.4180	6	11
.0469		12	.1719	2	12	.2969	4	12	.4219	6	12
.0508		13	.1758	2	13	.3008	4	13	.4258	6	13
.0547		14	.1797	2	14	.3047	4	14	.4297	6	14
.0586		15	.1836	2	15	.3086	4	15	.4336	6	15
.0625	1	0	.1875	3	0	.3125	5	0	.4375	7	0
.0664	1	1	.1914	3	1	.3164	5	1	.4414	7	1
.0703	1	2	.1953	3	2	.3203	5	2	.4453	7	2
.0742	1	3	.1992	3	3	.3242	5	3	.4492	7	3
.0781	1	4	.2031	3	4	.3281	5	4	.4531	7	4
.0820	1	5	.2070	3	5	.3320	5	5	.4570	7	5
.0859	1	6	.2109	3	6	.3359	5	6	.4609	7	6
.0898	1	7	.2148	3	7	.3398	5	7	.4648	7	7
.0938	1	8	.2188	3	8	.3437	5	8	.4687	7	8
.0977	1	9	.2227	3	9	.3476	5	9	.4727	7	9
.1016	1	10	.2266	3	10	.3516	5	10	.4766	7	10
.1055	1	11	.2305	3	11	.3555	5	11	.4805	7	11
.1094	1	12	.2344	3	12	.3594	5	12	.4844	7	12
.1133	1	13	.2383	3	13	.3633	5	13	.4883	7	13
.1172	1	14	.2422	3	14	.3672	5	14	.4922	7	14
.1211	1	15	.2461	3	15	.3711	5	15	.4961	7	15
.1250	2	0	.2500	4	0	.3750	6	0	.5000	8	0

It is believed that alloys are more perfect when compounded according to atomic proportions, or by multiples of their chemical equivalents, instead of by volumes. The chemical equivalents of the metals upon the hydrogen scale, now most usually adopted, are appended to the following list of metals : —

METALS.

	Melting-point.	Specific Gravity.	Chemical Equivalents.
Aluminium (about)	700 ° F.	2.56	13.75
Antimony	800	6.712	64.6
Arsenic	?	5.8	37.7
Bismuth	500	9.822	71.0
Cadmium	442	8.60	55.8
Cobalt	2500	8.53	29.5
Copper	2000	8.86	(cast) 31.6
Gold	2016	19.3	199.2
Iron (wrought)	3280	17.6	28.
Iron (cast)	2786	7.807	28.
Lead	612	11.44	103.6
Manganese	2700	6.85	27.7
Mercury (boils at)	670	13.5	202.0
Nickel	2500	8.27	29.5
Palladium	hardly fusible	11.3	53.3
Platinum	" "	21.5	98.8
Rhodium	" "	11.0	52.2
Silver	1873 ° F.	10.4	(cast) 108.0
Tin	442	7.28	57.9
Zinc	773	6 8	32.3

For a more complete list see ATOMIC WEIGHTS OF METALS ; METALS.

Alloys of greater Specific Gravity than the Mean of their Components.

Gold and Zinc.	Copper and Zinc.
Gold and Tin.	Copper and Tin.
Gold and Bismuth.	Copper and Palladium.
Gold and Antimony.	Copper and Bismuth.
Gold and Cobalt.	Copper and Antimony.
Silver and Zinc.	Lead and Bismuth.
Silver and Lead.	Lead and Antimony.
Silver and Tin.	Platinum and Molybdenum.
Silver and Bismuth.	Palladium and Bismuth.
Silver and Antimony.	

Alloys having a Specific Gravity inferior to the Mean of their Constituents.

Gold and Silver.	Iron and Bismuth.
Gold and Iron.	Iron and Antimony.
Gold and Lead.	Iron and Lead.
Gold and Copper.	Tin and Lead.
Gold and Iridium.	Tin and Palladium.
Gold and Nickel.	Tin and Antimony.
Silver and Copper.	Nickel and Arsenic.
Copper and Lead.	Zinc and Antimony.

(*Remarks.*) The various proportions and relative qualities as to melting-point and gravity are collected from a multitude of sources, the best attainable. The authorities, however, differ somewhat widely, and this can only be accounted for from the fact that so few metals can be obtained pure. The differences in the metals obtained from different localities are often unsuspected, and are fully proven in the variable statements of the cohesion in the tables compiled by Muschenbroek, Tredgold, Barlow, Brown, Rumford, Rennie, Telford, Bramah, and others.

The difficulty that has thus arisen has caused variable statements in the formulas for bell and ordnance casting, and has very considerably affected the exactness of statement in all the alloys, especially the more fusible ones, where the various combinations of lead, tin, and bismuth give such variable results.

It appears to be scarcely possible to give any sufficiently general rules, by which the properties of alloys may be safely inferred from those of their constituents ; for although, in many cases, the working qualities and appearance of an alloy may be nearly a mean proportional between the nature and qualities of the metals composing it, yet in other and frequent instances the deviations are excessive, as will be seen by several of the examples following.

Thus, when lead, a soft and malleable metal, is combined with antimony, which is hard, brittle, and crystalline, in the proportions of from twelve to fifty parts of lead to one of antimony, a flexible alloy is obtained, resembling lead, but somewhat harder, and which is rolled into sheets for sheathing ships. Six parts of lead and one of antimony are used for the large, soft printers' types, which will bend slightly, but are considerably harder than the foregoing ; and three parts of lead and one of antimony are employed for the smallest types, that are very hard and brittle, and will not bend at all ; antimony being the more expensive metal, is used in the smallest quantity that will suffice. The difference in specific gravity between lead and antimony constantly interferes, and unless the type-metal is frequently stirred, the lead, from being the heavier metal, sinks to the bottom, and the antimony is disproportionally used from the surface. In the above examples, the differences arising from the proportions appear intelligible enough, as, when the soft lead prevails, the mixture is much like the lead ; and as the hard, brittle antimony is increased, the alloy becomes hardened and more brittle ; with the proportion of four to one, the fracture is neither reluctant like that of lead, nor foliated like antimony, but assumes very nearly the grain and color of some kinds of steel and cast-iron. In like manner, when the tin and lead are alloyed, the former metal imparts to the mixture some of its hardness, whiteness, and fusibility, in proportion to its quantity, as seen in the various qualities of pewter, in which, however, copper and sometimes zinc or antimony are found. The same agreement is not always met with ; as nine parts of copper, which is red, and one part of tin, which is white, both very malleable and ductile metals, make the tough, rigid metal used in brass ordnance, from which it obtains its modern name of gun-metal, but which neither admits of rolling nor drawing into wire ; the same alloy is described by Pliny as the soft *bronze* of his day. The continual addition of the tin, the *softer metal*, produces a gradual increase of hardness in the mixture ; with about one sixth of tin the alloy assumes its maximum hardness consistent with its application to mechanical uses ; with one fourth to one third tin it becomes highly elastic and sonorous, and its brittleness rather than its hardness is greatly increased.

When the copper becomes two parts, and the tin one part, the alloy is so hard as not to admit of being cut with steel tools, but crumbles under their action ; when struck with a hammer, or even suddenly warmed, it flies in pieces like glass, and clearly shows a structure highly crystalline, instead of malleable. The alloy has no trace of the red color of the copper, but it is quite white, susceptible of an exquisite polish, and, being little disposed to tarnish, it is most perfectly adapted to the reflecting speculums of telescopes and other instruments, for which purpose it is alone used.

Copper, when combined in the same proportions with a different metal, also light-colored and fusible, namely, two parts of copper with one of zinc (which latter metal is of a bluish-white, and crystalline, whereas tin is very ductile), makes an alloy of entirely opposite character to the speculum

metal; namely, the soft yellow brass, which becomes by hammering very elastic and ductile, and is very easily cut and filed.

Again, the same proportions — namely, two parts of copper and one of lead — make a common inferior metal, called pot-metal, or cock-metal, from its employment in those respective articles. This alloy is much softer than brass, and hardly possesses malleability; when, for example, the beer-tap is driven into the cask, immediately after it has been scalded, the blow occasionally breaks it in pieces, from its reduced cohesion.

Another proof of the inferior attachment of the copper and lead exists in the fact that, if the molds are opened before the castings are almost cold enough to be handled, the lead will ooze out, and appear on the surface in globules. This also occurs to a less extent in gun-metal, which should not on that account be too rapidly exposed to the air; or the tin *strikes to the surface*, as it is called, and makes it particularly hard at those parts, from the proportional increase of the tin. In casting large masses of gun-metal, it frequently happens that little hard lumps, consisting of nearly half tin, work up to the surface of the runners, or pouring-places, during the time the metal is cooling.

In brass this separation scarcely happens, and these molds may be opened whilst the castings are red-hot without such occurrence; from which it appears that the copper and zinc are in more perfect chemical union than the alloys of copper with tin and with lead.

The malleability and ductility of alloys are in a great measure referable to the degrees in which the metals of which they are respectively composed possess these characters.

Lead and tin are malleable, flexible, ductile, and inelastic whilst cold, but when their temperatures much exceed about half-way toward their melting-heats, they are exceedingly brittle and tender, owing to their reduced cohesion.

The alloys of lead and tin partake of the general nature of these two metals; they are flexible when they are cold, even with certain additions of the brittle metals, antimony and bismuth, or of the fluid metal, mercury; but they crumble with a small elevation of temperature, as these alloys melt at a lower degree than either of their components, to which circumstance we are indebted for the tin solders.

Zinc, when cast in thin cakes, is somewhat brittle when cold, but its toughness is so far increased when it is raised to about 300° Fah. that its manufacture into sheets by means of rollers is then admissible; it becomes the malleable zinc, and retains the malleable and ductile character in a moderate degree, even when cold, but in bending rather thick plates it is advisable to warm them to avoid fracture. When zinc is remelted, it resumes its original crystalline condition.

Zinc and lead will not combine without the assistance of arsenic, unless the lead is in very small quantity; the arsenic makes this and other alloys very brittle, and it is, besides, dangerous to use. Zinc and tin make, as may be supposed, somewhat hard and brittle alloys, but none of the zinc alloys, except that with copper to constitute brass, are much used.

Gold, silver, and copper, which are greatly superior in strength to the fusible metals above named, may be forged, either when red-hot or cold, as soon as they have been purified from their earthy matters and fused into ingots; and the alloys of gold, silver, and copper are also malleable, either red-hot or cold. Fine or pure gold and silver are but little used alone; the alloy is, in many cases, introduced less with the view of depreciating their value, than of adding to their hardness, tenacity, and ductility. The processes which the most severely test these qualities, namely, drawing the finest wires, and beating gold and silver leaf, are not performed with the pure metals, but gold is alloyed with copper for the red tint, with silver for the green, and with both for intermediate shades. Silver is alloyed with copper only, and when the quantity is small its color suffers but slightly from the addition, although all its working qualities are greatly improved, pure silver being little used.

The alloys of similar metals having been considered, it only remains to observe that when dissimilar metals are combined, as those of the two opposite groups, namely, the fusible lead, tin, or zinc, with the less fusible copper, gold, or silver, the malleability of the alloys, when cold, is less than that of the superior metal, and when heated barely to redness they fly in pieces under the hammer; and therefore brass, gun-metal, etc., when red-hot, must be treated with precaution and tenderness. Muntz's patent metal, which is a species of brass and is rolled red-hot, appears rather a contradiction to this; but in all probability this alloy, like the ingots of cast-steel, requires at first a very nice attention to the force applied. It will be also remembered the action of rollers is more regular than that of the hammer, and soon gives rise to the fibrous character, which, so far as it exists in metals, is the very element of strength, when it is uniformly distributed throughout their substance.

The strength or cohesion of the alloys is in general greatly superior to that of any of the metals of which they are composed. For example, the relative weights which tear asunder a bar of one inch square of the several substances stand as follows, — all the numbers being selected from Muschenbroek's valuable investigations, so that it may be presumed the same metals, and also the same means of trial, were used in every case: —

Alloys.					Cast Metals.	
				lbs.		lbs.
10	Copper,	1	Tin,	32,093	Barbary Copper,	22,570
8	"	1	"	36,088	Japan "	20,272
6	"	1	"	44,071	English Block Tin,	6,650
4	"	1	"	35,739	" " "	5,322
2	"	1	"	1,017	Banca Tin,	3,679
1	"	1	"	725	Malacca Tin,	3,211

The inspection of these numbers is highly conclusive, and it shows that the engineer agrees with the theory and experiment in selecting the proportion six to one as the strongest alloy; and that the optician, in choosing the most reflective mixture, employs the weakest but one, its strength being only one third to one sixth that of the tin, or one twentieth that of the copper, which latter constitutes two thirds its amount.

See Holtzapffel's "Turning and Mechanical Manipulation," Art. "ALLOYS."

It is much to be regretted that the valuable labors of Muschenbroek have not been followed up by other experiments upon the alloys in more general use.

One curious circumstance will be observed, however, in those which are given, namely, that in the following alloys, which are the strongest of their respective groups, the tin is always four times the quantity of the other metal; and they all confirm the circumstance of the alloys having mostly a greater degree of cohesion than the stronger of their component metals.

Alloys.		Cast Metals.	
	lbs.		lbs.
4 English Tin, 1 Lead,	10,607	Lead,	885
4 Banca Tin, 1 Antimony,	13,480	Antimony,	1,060
4 " " 1 Bismuth,	16,692	Zinc,	2,689
4 English Tin, 1 Goslar Zinc,	10,253	Bismuth,	3,008
4 " " 1 Antimony,	11,323	Tin,	3,211 to 6,650

For other matter in regard to metals, see METALS.

The varieties of alloys are considered under their specified heads as follows : —

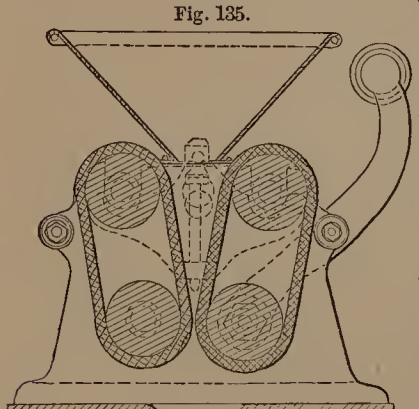
Aich's metal.
Albata.
Aluminium bronze.
Argentum mosaicum.
Artimourantico.
Aurum mosaicum.
Babbitt metal.
Bath metal.
Bell-metal.
Biddery ware.
Billon.
Blanched copper.
Brass.
Britannia metal.
Bronze.
Calin.
Caracoli.
Clinquant.
Electrum.
Expanding alloys.
Fusible alloys.
German metal.
German silver.
German steel.
German tutania.
German white copper.
Gold-solder.
Gun-metal.
Hard solder.
Imitation gold.
Journal-box metal.
Manheim gold.
Minargent.
Mock gold.
Mock platinum.
Mock silver.
Mosaic gold.
Muntz's metal.
Oreide.
Packfong.
Parisian gold-colored alloy.
Parisian white metal.
Petong.
Pewter.
Pewterer's solder.
Pewterer's temper.
Plumber's solder.
Pot-metal.
Queen's metal.
Red brass.
Red tombac.
Rosthorn's gun-metal.
Sabot metal.
Semilor.
Sheathing-metal.
Shot-metal.
Silver-solder.
Soft solder.
Solder.
Spanish tutania.
Speculum metal.
Spelter solder.
Statuary brass.
Stereotype metal.
Tinman's solder.
Tombac.
Tula metal.
Tutenag.
Type-metal.
White brass.
White malleable alloy.
White metals.
Wootz.
Yellow metal.

Al'ma-dy. (*Vessel.*) An African canoe made of the bark of trees.

Al'man. (*Metallurgy.*) A furnace used by refiners for separating metals. See ALMOND-FURNACE.

Al'mond-fur'nace. The word is probably corrupted from Alman (*Allemand*, German) furnace.

Fig. 135.



Wathew's Almond-Peeler.

A furnace used by refiners for separating all kinds of metals from cinders, etc.

Al'mond-peel'er. A small machine used by confectioners and cooks.

WATHEW'S almond-peeler, October 30, 1866. The thin peel is removed from the scalded almond kernels by passing them between two elastic bands of India-rubber, traversing side by side in the same direction, at different velocities.

Almonds came from Persia, and were introduced into England, 1570.

Al'mu-can'ter Staff. An instrument having an arc of 15°, formerly used to obtain observations of the sun's amplitude at the time of its rising and setting, to find the variation of the compass.

Al-pac'a. (*Fabric.*) *a.* A cloth in which the wool of the alpaca (a species of the llama, inhabiting Peru) is combined with wool, silk, or cotton.

b. A soft dress-goods, an imitation of the former ; having a cotton chain and woolen filling, plain color and highly finished surface.

Al'pha-bet Tel'e-graph. An apparatus which marks symbols on paper by pressure, as Morse's ; or by chemical action, as Bain's ; or impresses type on paper, as House's or Hughes's ; in contradistinction to one whose indications are observed by the fluctuating position of a needle or needles, as Cooke and Wheatstone's, or the bell-telegraph of Bright. See RECORDING TELEGRAPH.

Al-phon'sin. (*Surgical.*) A kind of bullet-forceps. Named from Alphonsus Ferrier of Naples.

Al'tar. 1. The low ridge which intervenes between the puddling-hearth and the stack.

2. One of the *steps* at the side of a graving-dock. The steps are from nine to sixteen inches in hight, and from nine to fifteen inches wide, except the *broad altar*, which is eighteen inches wide.

Alt-az'i-muths. See THEODOLITE ; TRANSIT.

Al-tim'e-ter. An instrument for taking altitudes geometrically, or for measuring vertical angles, as the quadrant, sextant, etc., or the vertical limb of the theodolite.

One of the first references to means for measuring height is in connection with the most worthy artificial object in the world, then or now. Thales is said, by Plutarch, to have been in Egypt in the reign of Amasis, and to have taught the Egyptians how to measure the height of the pyramid by its shadow. This is interesting from its association of names and places, but is absurd in itself. Thales went to Egypt to learn, not to teach. During the reign of the same king, Egypt was visited by Pythagoras and Anacreon, the friends of Polycrates of Samos ; Pythagoras, among other things, learned to abominate beans, the peculiar aversion of the Egyptian priests. Egypt was also visited about this time by Solon (Herodotus, I. 30), who came as a student, and afterwards introduced some of the Egyptian laws into his Athenian code.

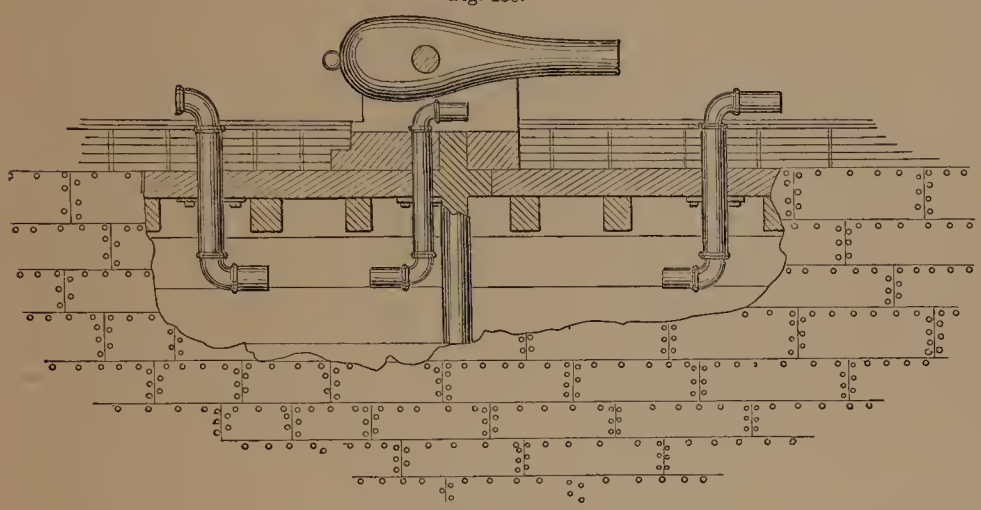
Al-tin'car. (*Metallurgy.*) A factitious kind of salt used in separating metals.

Al'ti-scope. CLARK, March 13, 1866. This invention consists of an arrangement of lenses and mirrors in a vertical telescopic tube, by means of which a person is able to overlook objects intervening between himself and the object he desires to see. When the sections of the tube are extended, the view is received upon an upper mirror placed at an angle of 45° and reflected thence down the tube to a lower mirror, where it is seen by the observer. The image is magnified by lenses intervening between the mirrors. The telescopic tubes are so connected that each in turn acts upon the next in series, as it comes to the end of its own range, and thus the desired elevation is arrived at. The means of extension is a winch and cords.

STEVENS, January 6, 1863. This affords a means for training guns to a given angle with the axis of the vessel, or on an object, while the gunner re-

mains beneath the gun-deck. There is attached beneath the deck to the pintle of the pivoted gun a graduated index-plate, by which its horizontal bearing may be read. A telescopic tube, with two rectangular bends and with reflecting mirrors at the angles, is so placed as to be used from beneath the deck; two of these may be so situated as to form a base of sufficient length to obtain, by simultaneous observation, the distance by triangulation. Two screw-propellers, working in contrary directions, rotate the vessel so as to bring the guns to bear on the required point.

Fig. 136.



Stevens's Altiscope.

The upper and lower limbs of the telescopic tube are parallel; the one above deck is presented towards the object, the other to the eye. The image of the object, after being twice reflected, reaches the eye of the observer, whose person is not exposed.

A portable altiscope, adapted to enable a person to look over the heads of a crowd, is formed of a hollow cane with perforations near its respective ends, opposite two reflectors arranged at angles of 45° in the cane. The cane being held vertically, and the upper orifice presented towards the object to be viewed, — a speaker, for instance, — the image is received upon one mirror and passes down the cane to the other, where it is observed by the person. Slides cover the openings when not used for observations, and the cane has then an ordinary appearance.

Al'ti-tude In'stru-ments. Theodolites, sextants, transit instruments, and many others having specific names, are used for taking altitudes, while some of them have also adjustments in azimuth. These are treated specially under the above and other titles, and are also referred to under ASTRONOMICAL INSTRUMENTS.

The *altitude and azimuth* circle is used for measuring the altitudes and azimuths of stars, as its name implies, and is composed of two graduated circles, one vertical and the other horizontal.

It is thus of general application.

Jean Picard, the great French astronomer, 1620–1684, is said to have been the first to apply the telescope in the measurements of angles.

Al-tom'e-ter. A name for the theodolite, which see.

Al'to-ri'li-e'vo. The high relief of a sculptured object from the plane surface to which it is attached.

The degrees of prominence of the object are indicated by the terms: —

Alto, or *high-relief*, when the object projects more than half its thickness, frequently being attached at a few places to the plane surface.

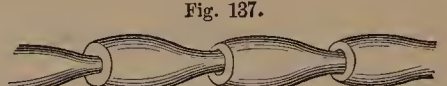
Mezzo, or *demi-relief*, less prominent, say one half the thickness or a little less than half.

Basso, or *low-relief*, a slight prominence, as in medals and coins.

Al'u-del. A pear-shaped receiver, used in the Spanish furnaces for subliming mercury.

The aludels are fitted together longitudinally in a row, the neck of one fitting into the bulb of another, being luted together at the joints with softened loam. The mercury condenses in the aludels, and gradually works its way to the lower one of the series, which is tapped to allow the metal to flow off.

Fig. 137.



Aludel.

The *aludel furnace* has a vaulted chamber above the fuel chamber, and in the former the blocks of cinnabar are built up. The fumes of the metal pass into a number of strings of *aludels*, and, being condensed, are received in a common duct which leads to a reservoir.

Al'u-min'i-um. Equivalent, 13.7; symbol, Al.; specific gravity, 2.56 cast, 2.67 hammered; fusing-point, 1250° Fah.

Next to silica, the oxide of aluminium (alumina) forms, in combination, the most abundant constituent of the crust of the earth (hydrated silicate of alumina, clay).

Common alum is sulphate of alumina combined with another sulphate, as potash, soda, etc. It is much used as a mordant in dyeing and calico-printing, also in tanning.

Aluminium is a shining, white, sonorous metal,

TABLE OF THE VISIBLE DISTANCE OF OBJECTS IN STATUTE MILES.

Height in Feet.	Distance in Miles.	Height in Feet.	Distance in Miles.	Height in Feet.	Distance in Miles.	Height in Feet.	Distance in Miles.
*.582	1.	11	4.36	30	7.18	150	16.05
1	1.31	12	4.54	35	7.76	200	18.54
2	1.85	13	4.71	40	8.3	300	22.7
3	2.27	14	4.9	45	8.8	400	26.2
4	2.62	15	5.07	50	9.37	500	29.3
5	2.93	16	5.24	55	9 72	1000	41.45
6	3.21	17	5.4	60	10.14	2000	58.61
7	3.47	18	5.56	70	10.97	3000	71.79
8	3.7	19	5.72	80	11.72	4000	82.9
9	3.93	20	5.86	90	12.43	5000	92.68
10	4.15	25	6.55	100	13.1	1 mile.	95.23

* For a statute mile the curvature = 6.99 inches.

having a shade between silver and platinum. It is a very light metal, being lighter than glass, and only one fourth as heavy as silver of the same bulk. It is very malleable and ductile; does not oxidize when exposed to moist or dry air, is not chemically affected by hot or cold water. Sulphureted hydrogen gas, which so readily tarnishes silver, forming a black film on the surface, has no action upon this metal.

Aluminium is of great value in mechanical dentistry, as, in addition to its lightness and strength, it is not affected by the presence of sulphur in the food, — as by eggs, for instance.

Dr. Fowler, of Yarmouthport, Mass., obtained patents for its combination with vulcanite as applied to dentistry and other uses, February 7 and 14, 1865. It resists sulphur in the process of vulcanization in a manner which renders it an efficient and economical substitute for platinum or gold.

Aluminium is derived from the oxide, alumina, which is the principal constituent of common clay. Lavoisier, a celebrated French chemist, first suggested the existence of the metallic bases of the earths and alkalies, which fact was demonstrated twenty years thereafter by Sir Humphry Davy, by eliminating potassium and sodium from their combinations; and afterwards by the discovery of the metallic bases of barytes, strontium, and lime. The earth alumina resisting the action of the voltaic pile, and the other agents then used to induce decomposition, twenty years more passed before the *chloride* was obtained by Oerstadt by subjecting alumina to the action of potassium in a crucible heated over a spirit-lamp. The discovery of aluminium was at last made by Wöhler in 1827, who succeeded in 1846 in obtaining minute globules or beads of this metal by heating a mixture of chloride of alumina and sodium. Deville afterwards conducted some experiments in obtaining this metal at the expense of Napoleon III., who subscribed £1,500, and was rewarded by the presentation of two bars of aluminium. The process of manufacture was afterwards so simplified that in 1857 its price at Paris was about two dollars an ounce. It was at first manufactured from common clay, which contains about one fourth its weight of aluminium, but in 1855 Rose announced to the scientific world that it could be obtained from a material called "cryolite," found in Greenland in large quantities, imported into Germany under the name of "mineral soda," and used as a washing-soda, and in the manufacture of soap. It consists of a double fluoride of aluminium and sodium, and only requires to be mixed with an excess of sodium, and heated, when the mineral aluminium at once separates. Its cost of manufacture is given in the following estimate: for one pound of metal,

16 lbs. of cryolite at 8 cts per pound . .	$1.28
2½ lbs. metallic sodium at about 26 cts per lb.	.70
Flux and cost of reduction . . .	2.02
	$4.00

Aluminium is used largely in the manufacture of cheap jewelry, by making a hard, gold-colored alloy with copper, called aluminium bronze, consisting of 90 per cent of copper and 10 per cent of aluminium. Like iron, it does not amalgamate directly with mercury, nor is it readily alloyed with lead, but many alloys with other metals, as copper, iron, gold, etc., have been made with it and found to be valuable combinations. One part of it to one hundred parts of gold gives a hard malleable alloy of a greenish-gold color, and an alloy of ¾ iron and ¼ aluminium does not oxidize when exposed to a moist atmosphere. It has also been used to form a metallic coating upon other metals, as copper, brass, and German silver, by the electro-galvanic process. Copper has also been deposited, by the same process, upon aluminium plates to facilitate their being rolled very thin; for unless the metal be pure, it requires to be annealed at each passage through the rolls, and it is found that its flexibility is greatly increased by rolling. To avoid the bluish-white appearance, like zinc, Dr. Stevenson McAdam recommends immersing the article made from aluminium in a heated solution of potash, which will give a beautiful white frosted appearance, like that of frosted silver.

F. W. Gerhard obtained a patent in 1856, in England, for an "improved means of obtaining aluminium metal, and the adaptation thereof to the manufacture of certain useful articles." Powdered fluoride of aluminium is placed alone or in combination with other fluorides in a closed furnace, heated to a red heat, and exposed to the action of hydrogen gas, which is used as a reägent in the place of sodium. A reverberatory furnace is used by preference. The fluoride of aluminium is placed in shallow trays or dishes, each dish being surrounded by clean iron filings placed in suitable receptacles; dry hydrogen gas is forced in, and suitable entry and exit pipes and stop-cocks are provided. The hydrogen gas, combining with the fluoride, "forms hydro-fluoric acid, which is taken up by the iron and is thereby converted into fluoride of iron." The resulting aluminium "remains in a metallic state in the bottom of the trays containing the fluoride," and may be used for a variety of manufacturing and ornamental purposes.

The most important alloy of aluminium is composed of

Aluminium . . .	10
Copper	90

It possesses a pale gold color, a hardness surpassing that of bronze, and is susceptible of taking a fine polish. This alloy has found a ready market, and, if less costly, would replace red and yellow brass. Its hardness and tenacity render it peculiarly adapted for journals and bearings. Its tensile strength is 100,000 lbs., and when drawn into wire 128,000 lbs., and its elasticity one half that of wrought-iron.

General Morin believes this alloy to be a perfect chemical combination, as it exhibits, unlike the gun-metal, a most complete homogeneousness, its preparation being also attended by a great development of heat, not seen in the manufacture of most other alloys. The specific gravity of this bronze is 7.7. It is malleable and ductile, may be forged cold as well as hot, but is not susceptible to rolling; it may, however, be drawn into tubes. It is extremely tough and fibrous.

Aluminium bronze, when exposed to the air, tarnishes less quickly than either silver, brass, or common bronze; and less, of course, than iron or steel. The contact of fatty matters or the juice of fruits does not result in the production of any soluble metallic salt, an immunity which highly recommends it for various articles for table use.

The uses to which aluminium bronze is applicable are various. Spoons, forks, knives, candlesticks, locks, knobs, door-handles, window-fastenings, harness-trimmings, and pistols are made from it; also objects of art, such as busts, statuettes, vases, and groups. In France, aluminium bronze is used for the eagles on military standards, for armor, for the

works of watches, as also watch-chains and ornaments. For certain parts, such as journals of engines, lathe-head boxes, pinions, and running gear, it has proved itself superior to all other metals.

Hulot, director of the Imperial postage-stamp manufactory in Paris, uses it in the construction of a punching-machine. It is well known that the best edges of tempered steel become very quickly blunted by paper. This is even more the case when the paper is coated with a solution of gum-arabic and then dried, as in the instance of postage-stamp sheets. The sheets are punched by a machine the upper part (head) of which moves vertically and is armed with 300 needles of tempered steel, sharpened in a right angle. At every blow of the machine, they pass through holes in the lower, fixed piece which correspond with the needles, and perforate five sheets at every blow. Hulot now substitutes this piece by aluminium bronze. Each machine makes daily 120,000 blows or 180,000,000 perforations, and it has been found that a cushion of the aluminium alloy was unaffected after some months' use, while one of brass is useless after one day's work.

ALUMINIUM ALLOYS.

	Aluminium.	Copper.	Iron.	Silver.	Zinc.
Gold-colored malleable Alloy	1	10			
Parisian gold-colored Alloy	10.5	89.3			
White malleable Alloy	2	10			
Hard Bronze	10	90			
Non-oxidizable Alloy	25		75		
Hard, bright (like silver) Alloy	100			5	
Baur's Patent, Oct. 27, 1863	$\frac{1}{10}$ to 3	14 - 16	Nickel.	Tungsten.	10
Minargent	10	1000	700	50	
			White Metal		
Farmer's Patent, Sept. 6, 1864		65 - 80	Zinc. $91\frac{11}{10}$ / Steel. $6\frac{7}{10}$ / Al. $1\frac{7}{10}$		20 - 35

Farmer's aluminium alloys, patent April 28, 1863. Copper is the first element, aluminium the second; the other light-colored metals are added singly or collectively, as by the following formulas, in which the proportions of atoms are stated. (See article Metals, for table of the chemical equivalents of the metals.

Ag., *Argentum*, — Silver. Al., *Aluminium*.
Cu., *Cuprum*, — Copper. Ni., *Nickel*.
Fe., *Ferrum*, — Iron. Zn., *Zinc*.

The four following formulas produce alloys which, from their color and fineness of texture, nearly resemble gold, whence they are termed chrysoid, being adapted for use in the manufacture of watch-cases, chains, and ornamental jewelry: —

	Cu.	Al.	Ag.
$Ag. + 24\ (Al._1 + Cu._6) =$	.9180 +	.0616 +	.0203
$Ag. + 24\ (Al._1 + Cu._7) =$	.9241 +	.0570 +	.0188
$Ag. + 24\ (Al._1 + Cu._8) =$	.9330 +	.0504 +	.0166
$Ag. + 24\ (Al._1 + Cu._9) =$	.9400 +	.0450 +	.0150

The three following formulas produce alloys for journal-boxes, etc. for machinery: —

	Cu.	Al.	Zn.
$Zn. + 2\ (Al._1 + Cu._6) =$	.8643 +	.0622 +	.0734
$Zn. + 2\ (Al._1 + Cu._9) =$	.9053 +	.0435 +	.0512
$Zn. + 2\ (Al._1 + Cu._{12}) =$	.9273 +	.0333 +	.0394

These alloys are hard and tenacious, but are characterized by considerable shrinkage in cooling from a molten state, the last-mentioned alloy having considerably more shrinkage than either of the others preceding it. The said alloys have, when drawn into wires of about one thirtieth of an inch in diameter, a tensile strength to the square inch of section in the preceding order of about 90,000, 103,000, and 84,000 lbs.

The following alloys are adapted for gun-metal, being hard, tenacious, laminable, and ductile.

	Cu.	Al.	Fe.
$Fe._1 + (Al._1 + Cu._{15}) =$	.9203 +	.0267 +	.0530
$Fe._1 + (Al._1 + Cu._9) =$	.9399 +	.0446 +	.0149

	Cu.	Al.	Zn.	Fe.
$Fe._1 + Zn._1 + (Al._1 + Cu._{12}) =$	.8386 +	.0302 +	.0712 +	.0600
$Fe._1 + Zn._1 + (Al._1 + Cu._{15}) =$	.8666 +	.0249 +	.0588 +	.0496

The tensile strength of the above alloys when reduced to wire, as above referred to, is for the square inch of section about 82,000 lbs. for the first of the last series of formulas, 84,500 lbs. for the second, and 107,700 lbs. for the last.

Where zinc or tin, or both, enter into the alloys in place of silver, the color of the resultant alloys is somewhat affected, and the luster is diminished.

In the following alloys nickel forms the third element of the combination of the first formula and platinum the third element of the combination of the second formula.

	Cu.	Al.	Ni.
Ni. 1 + 6 $(Al._1 + Cu._6) =$	.9129 +	.0634 +	.0237.
	Cu.	Al.	Pl.
Pl. 1 + 21 $(Al._1 + Cu._6) =$	.9117 +	.0656 +	.0225.

Those alloys into which platinum is introduced are less affected by acids than those in which silver takes the place of platinum; either the platinum or the silver gives a high luster to the alloy, platinum producing this result in a greater degree than silver.

In those alloys in which are introduced iron or other light-colored metals, which are difficult of fusion, it is preferable to bring the easily fused metals into a molten state, and then to mix those less fusible with them in the form of shreds, particles, fine wire, or thin plates.

Aluminium and its alloys are combined with vulcanite in the patents of Fowler, February 7 and 14, 1865.

According to some analyses, wootz (East Indian steel) is alloyed with aluminium.

Lancaster's (1858, England) gun-metal: copper, 90; aluminium, 100.

Al'um Leath'er. Leather tanned by a composition of alum and salt. Three pounds of salt and four of alum are used to one hundred and twenty middle-sized skins, which are placed in a tumbling-box with a sufficient quantity of water. The process, with the succeeding operations, is described under Tawing, which see.

Alum was used as a tanning agent by the Saracens.

Al've-o-lar For'ceps. A cutting-forceps or nippers for gnawing away protruding portions of the alveolar ridge, to get a better base for a denture, or to remove points which prevent the healing of the gums.

Am'a-a'sa. Pieces of glass used in enameling.

A-mal'gams. An amalgam is a compound of mercury with another metal or metals. It differs from an alloy in possessing mercury as a constituent. Compounds of other metals, with no mercury included, are alloys, whatever may be their comparative quantities or complications. Mercury does not combine with all other metals, but unites with notable readiness with gold, silver, copper, zinc, tin, lead, palladium, and bismuth. It is the great means

of selecting and aggregating by absorption particles of gold and silver which are set free by the comminution of their matrix, but are so distributed in the powder as to require a congregating agent. The quartz rock having been pounded or ground so as to reduce it to powder, loosening the firm bond of the rock upon the particles of metal distributed through it, the mercury is well mixed with the dust, water being added to form a pulp. The mercury insinuates itself throughout the mass, and absorbs the precious metals therein. Being removed from the sand and dust of the rock, the quicksilver is set free by sublimation, leaving the non-vaporizable metals in the retort. The quicksilver fumes are gathered and condensed for re-use.

Pliny says, "The most convenient mode of gilding copper is to employ mercury, which is applied in the form of an amalgam to the copper, to enable it to retain the gold leaf when laid thereon." They also understood the art of obtaining mercury by sublimation of cinnabar, or by stamping and application of vinegar. In the process by destructive distillation, the cinnabar was placed in a flat earthen pan covered with a lid and then enclosed in an iron pot luted with clay. Heat being applied, the fumes were condensed and collected in globules on the lid.

In some cases the quicksilver is presented in the form of vapors which condense and unite with the metals to form an amalgam.

Auriferous sands are subjected to the same process of amalgamation by bringing them in contact with a body of mercury. The mechanical processes are described under AMALGAMATORS, which see.

The application of an amalgam of sodium and mercury in extracting precious metals was invented by Wurtz of New York, and patented in the United States, June 27, 1865. Crookes, of England, subsequently to the date of Wurtz's application for United States patent, made application for a patent in England for the same invention.

The extraction of the precious metals by amalgamation has hitherto been much impeded and its cost increased by the presence in the ores of compounds of sulphur, arsenic, antimony, bismuth, or tellurium, which, by covering the gold with a thin film of tarnish, prevent its entering into combination with the mercury. The use of sodium amalgam, under these circumstances, is to prevent the "sickening" and "flouring" of mercury which the presence of these compounds, and especially of sulphate of iron, is so apt to produce.

The official statement of Wurtz's invention is as follows: This inveution consists in adding to quicksilver, to be used in the amalgamation of gold, silver, etc., a small quantity of an amalgam of mercury and sodium, or other equivalent metal, as potassium; by this addition the mercury more readily attacks the precious metals. Mercury treated in this way will also form a mercurial film or coating on iron or steel, so as to form amalgamated surfaces, to take the place of the usual copper plates. The mercury so treated is less liable to "flour."

Claim. — First, the combination with quicksilver, when used for the extraction by amalgamation of metals from their ores or their mixtures with other materials, of metallic sodium or metallic potassium, or any other highly electro-positive metal equivalent in its action thereto, as above set forth.

Second, in those amalgamations in which amalgamated plates of copper or other metal are used, the substitution for the plates of copper or other metal of iron coated with quicksilver combined with sodium or other highly electro-positive metal, as above set forth.

Third, the coating of iron, steel, or other metallic surfaces between or under which ores or other materials are crushed, with quicksilver combined with sodium or other highly electro-positive metal, as above set forth.

Fourth, the prevention of the granulation or flouring of quicksilver when used in any method of amalgamating ores or other materials by addition thereto of sodium or other highly electro-positive metal, as above set forth.

The valuable work of Phillips on mining gives the compendium following: A quantity of sodium amalgam dissolved in a hundred times or more its weight of quicksilver is said to communicate to the whole a greatly enhanced power of adhering to metals, and particularly to those which, like gold and silver, are situated toward the negative extremity of the electro-chemical scale. This power of adhesion in the case of the two metals is so great that the resistance which their surfaces, when in their native state, often oppose to amalgamation (a resistance much greater, and more general than has been hitherto recognized, and due to causes as yet uninvestigated) is instantly overcome, whether their particles be coarse or impalpable. Even an artificial coating of oil or grease, which is usually such an enemy to the combination of mercury with other metals, forms no obstacle to immediate amalgamation by this prepared quicksilver. The atoms of quicksilver are, as it is described, put into a sort of polaric condition by a minute addition of one of the metals which range themselves toward the electro-positive end of the scale; so that its affinity for the more electro-negative metals is stated to be so greatly exalted that it seizes upon and is instantaneously absorbed by their surfaces, just as water is absorbed by a lump of sugar, or other porous substance soluble in it.

Such quicksilver even adheres strongly to surfaces of iron, steel, platinum, aluminium, and antimony; an adhesion which, however, in the case of these metals, is not a true amalgamation, there being no penetration into the substance of the metal; so that the superficially adherent quicksilver may be readily wiped off, just as water may be removed from glass. The only metal as yet experimented on, which cannot be enfilmed by the use of sodium amalgam, appears to be magnesium.

Application of Sodium Amalgam to Working Ores of the Precious Metals.

This consists in adding from time to time, to the quicksilver used in amalgamation, about one hundredth part of its weight of sodium amalgam. The frequency with which the amalgam is to be added cannot be exactly specified, as it will be found to depend on a multitude of circumstances, — such, for instance, as the temperature, the purity and quantity of the water used, the ratio borne by the surface of the quicksilver to its mass, the amount and mode of agitation of the quicksilver, the nature of the process and apparatus used, the character of the ore, strength of the amalgam, etc.; so that this important point can only be determined in each case by experience. Some general indications may, however, be derived from the experiments which have been made. It is said that less sodium is requisite in cases in which much water is employed, and when the water is frequently renewed, — as, for instance, in the riffles of a sluice, and in all forms of amalgamators through which a continual current of water is kept running, — since mercurial solutions of sodium are but little affected by water free from acid, alkaline, or saline impurities.

In cases, however, in which but little water is

employed, and especially where the ore and quicksilver are ground together into a slime, the water soon becomes alkaline, and oxidation of the sodium sets in, necessitating its frequent renewal.

In such cases the following manipulation is recommended. The whole amount of quicksilver to be used for working up a batch of slimes, say fifty pounds, is prepared by dissolving in it one per cent of amalgam No. 2, or better, two per cent of the soft amalgam No. 1, which dissolves more readily; one half, or twenty-five pounds, is then thrown into the mill with the ore, and, as the incorporation proceeds, certain fractional parts of the other half are added at intervals, varying according to circumstances, until the whole has been introduced. If, as is usual, the quicksilver has been separated from the slimes of a previous operation, it will retain a certain amount of sodium, and therefore require fresh amalgam in proportionately smaller quantities.

No. 1 amalgam contains two per cent and No. 2 four per cent of sodium; the latter is a hard, brittle solid, remarkably infusible, requiring a temperature nearly as high as the fusing-point of type-metal to melt it, and may be cast into ingots, and packed either under petroleum, or in air-tight iron cans filled with dry lime.

In sluicing operations, the soft amalgam No. 1 is, on account of its ready solubility in mercury, most recommended; and in these cases it is practicable to test the quicksilver in the riffles, and ascertain when the magnetic quality requires restoration, by throwing in a few grains of gold-dust. Similar tests are easily applied to slimes, and in amalgamating generally, a slip of tarnished sheet-copper is a suitable agent for such testings. It may be remarked that the amalgam No. 1 is at any time easily prepared from No. 2, by melting it in an iron ladle with its own weight of quicksilver. In copper-plate amalgamation — that is, in cases in which auriferous materials are brought into contact with amalgamated metallic surfaces — it is recommended to substitute for quicksilver itself the pasty amalgam No. 2.

In these modes of amalgamation great economy in wear and tear of apparatus, as well as in first cost, is said to be effected by using plates or surfaces of iron instead of copper. The power of coating or enfilming iron is stated to render these amalgams peculiarly valuable in every form of apparatus for amalgamation which has internal surfaces of iron; for these, becoming coated with quicksilver, immensely extend its chances of contact with particles of gold, so fine as to remain suspended in the water. Other important services are expected by the inventors to arise out of this power of enfilming iron, such as keeping the surfaces of stamps and of other apparatus used in crushing ores continually coated. In like manner, as the power of adhesion of quicksilver to other metals is exalted by the presence of the alkali-metals, so also is its own cohesion stated to be greatly increased. It is rendered more difficult to mechanically divide, and when thus divided again runs instantly together upon contact. Hence new results of great value are said to have been obtained. For instance, the so-called "flouring" or granulation of quicksilver, which in the amalgamation of ores always occasions losses both of the quicksilver itself and of its amalgams with the precious metals, is stated to be reduced to a minimum, or altogether prevented.

The recovery of "floured" quicksilver and amalgams from slimes and similar mixtures is also said to be greatly facilitated and accelerated thereby. For this purpose some sodium amalgam is thrown into the separator, and collects and incorporates all the scattered globules of auriferous amalgam. It is here necessary to call attention to a method of manipulation generally applicable when sodium amalgams are used, and particularly so in all cases in which the ore is ground or agitated with quicksilver in contact with metallic iron. This arises from the liability of abraded particles of iron to adhere to the amalgam.

The following plan is, therefore, in such cases recommended. The amalgam, after separation from excess of quicksilver, and before retorting, is fused in an earthen dish or iron ladle, with, if necessary, the addition of a little quicksilver to make it more liquid; and the iron, which forms a scum on the surface, is skimmed off. The excess of quicksilver may, after cooling, be again separated from the amalgam in the usual way. Any amalgam which adheres to the iron scum is readily detached by boiling in water to remove the sodium. This process depends on the fact that adhesion to the iron totally disappears with the extraction of the last traces of sodium from the quicksilver. It is, in fact, possible to remove all iron from the amalgam by boiling in water without any previous fusion, particularly if the water be made somewhat acid or alkaline. The presence of iron can be readily detected by the magnet, which may also be sometimes used with advantage in separating iron from amalgam after all the sodium has been extracted. There are still other substances which may be found adherent to the amalgam when sodium has been used, such as platinum, or osmiridium, or both, with iron, and these may be freed from the latter by the magnet.

The sodium amalgams prepared in accordance with the recipes of Mr. Crookes are known respectively as *A*, *B*, and *C* amalgams.

Each of these contains three per cent of sodium, in addition to which *B* has a small quantity of zinc in its composition, and *C* a little tin. An amalgam (*A*), of seven times the strength of the above, is prepared in solid bars for shipment when the expense of freight or land carriage is great. Amalgams *B* and *C* cannot be prepared in the concentrated form. It is recommended that one part by weight of amalgam *B* or *C* be dissolved in thirty parts of the mercury which is to be used in the amalgamating, triturating, or grinding machines, and the effect which it produces on the mercury noted from time to time during the operation. If it retain its fluidity and brightness to the end of the operation, it is a sign either that a sufficient amount or too much has been added, and a second experiment should be tried with a less quantity of amalgam. But if it be "floured," or "sickened," or any loss occur, more amalgam may be added until the best proportion is arrived at.

Mr. Crookes states that amalgam *B* will generally be found effective, but if the ore contain an excess of any mineral which has a deleterious action on mercury, more especially if it contain bismuth, it will be advantageous to employ amalgam *C* instead of *B*.

When the best proportion of amalgam *B* or *C* is determined, small quantities of amalgam *A* should be introduced into the mercury, already containing amalgam *B* or *C*, in the proportion of one part of amalgam *A* to one thousand of mercury. This quantity of amalgam *A* can be added every few hours, according to circumstances, but one charge of amalgam *B* or *C* will, it is stated, usually be sufficient for several days. Under some circumstances it will be found advisable to add amalgam *B* or *C* every few days, but a little experience and comparison with the results obtained by the old plan

will soon show how these several agents are best utilized.

The process of extraction of the precious metals by the lead-bath will be found under LEAD-BATH FOR THE EXTRACTION OF GOLD AND SILVER.

Other processes for gathering gold (excepting AMALGAMATORS, which see) are included under the general title GOLD-WASHER.

The ore-crushers are described under ORE-STAMPS, etc.; ORE-GRINDING MILLS; ARRASTRAS.

An amalgam of mercury and tin is used to coat the back of looking-glasses and glass mirrors.

This amalgam consists of mercury, 3; tin, 1. It is formed by laying a sheet of tin-foil on a table, covering it with mercury, and then, by a sliding movement, placing the sheet of glass over it.

An amalgam of gold is also used by jewelers to overlay other metals by a fine film of gold, after which the mercury is driven off by heat.

In Mallet's process (English) for preserving iron from rust and ship's sheathing from fouling, the iron is dipped in an amalgam of zinc, sodium, and mercury.

The process is as follows:—

The plates are cleansed in a warm solution of equal parts of acid (sulphuric or hydrochloric) and water. The scale and oxide are removed from the metal by scouring. The plate is then placed in a *preparing*-bath consisting of a saturated solution of hydrochlorate of zinc and sulphate of ammonia. It is then immersed in a bath formed of

Mercury	202
Zinc	1,292

To each 2,240 pounds of which amalgam 1 pound of potassium or sodium is added.

The iron is speedily heated, and is withdrawn before it reaches 680° Fah., at which temperature it would be soon dissolved by the alloy.

A similar process, so far as the manipulation is concerned, is passed through in the palladiumizing process, in which, after cleansing, the plates are immersed in a fused amalgam of palladium and mercury.

Amalgam for the electrical machine:—

Zinc	2
Tin	1
Mercury	4

Melted in the order named, in an iron spoon. Shake the fused amalgam till cold, triturate in a mortar; sift; rub up the powder with lard, and apply with a palette-knife to the rubber of the machine.

Amalgam for silvering the insides of hollow glass spheres:—

Mercury	3
Lead	1
Bismuth	1

A-mal'ga-ma'ting Zinc Plates. Zinc plates for the voltaic battery are amalgamated with mercury, so that no action of the sulphuric acid takes place on the zinc when the circuit is not closed.

To amalgamate the plates, they are first pickled in dilute sulphuric acid (acid 1, water 8) in a stone-ware pan. A little mercury, being poured into the pan, is rubbed on both sides of the plate by means of a swab. The plate is washed in clean water, placed on its edge to drain, again rubbed with mercury and drained.

Another method is to clean the plates with emery, pickle, and wash. Then dip the clean plates in a mixture of equal parts by weight of biehloride of mercury (corrosive sublimate) and acetate of lead. Rub with a cloth, and they are ready for use.

A-mal'ga-ma'tor. It appears from Pliny, A.D. 79, that the ancients were acquainted with amalgams, in their uses for separating gold and silver from earthy particles, and in gilding.

Pliny says: "Mercury is an excellent refiner of gold, for on being shaken in an earthen vessel with gold, it rejects all the impurities that are mixed with it. When once it has thus expelled these impurities, there is nothing to do but to separate it from the gold; to effect which it is poured upon leather, and exudes through it in a sort of perspiration, leaving the pure gold behind."

Vitruvius (B. C. 27) describes the manner of recovering gold from cloth in which it has been interwoven. The cloth, he says, is to be put in an earthen vessel, and placed over the fire in order that it may be burnt. The ashes are thrown into water, and quicksilver added to them. The latter unites with the particles of gold, the water is poured off, and the residue put into a cloth, which being squeezed with the hands, the quicksilver, on account of its fluidity, oozes through the pores, and the gold is left pure in a compressed mass. It is commonly stated that the ancients did not understand the art of recovering mercury by retort and receiver, but a description of the apparatus by Pliny (see AMALGAMS) contradicts this. It does not, however, seem to have been much practised.

In the year 1582, Herberer described the washing of gold as he saw it practised at Selz, not far from Strasburg, and at that time quicksilver had long been used for that purpose.

The cinnabar mines of Peru were discovered about 1566 by Garces, who observed the Indians using a native red earth for paint. It does not appear to have come into general use in the silver-mines of Peru, as a means of extracting the silver from the earthy particles, till 1571, when Pero Fernandas de Velasco came to Peru and offered to refine the silver by mercury, as he had seen in the smelting-houses in Mexico. His proposals were accepted, the old methods abandoned, and that of amalgamation pursued as it is practised at present.

In 1572, Hawks writes that "an owner of a mine must have much quicksilver, and as for this charge of quicksilver, it is a new invention, which they find more profitable than to fine their ore with lead."—*Hakluyt's Voyages.*

The number of patents granted in the United States for amalgamators cannot be readily stated, as so many of the crushers, grinders, and arrastras become amalgamators by the addition of mercury. To state the whole number would give an exaggerated view, as many of them are merely mechanical grinders without any specific adaptation to the requirements of the mercurial process. The number of patents for amalgamators in the United States may be approximately stated at two hundred and sixty, January, 1872.

With the exception of the argentiferous galena, silver is generally found in the form of brittle sulphides disseminated through the gangue or vein stone. These particles, in the operation of grinding or stamping, are reduced to a fine powder, which floats off in water in the process of concentration. It becomes necessary, therefore, to apply a gathering agent which will collect them, and the notable activity of quicksilver in entering into combination with the precious metals has caused its selection as the desired agent. The subject is specially treated under AMALGAMS, and the mechanical processes and manipulation are the subject of this article.

The processes and machines for the amalgamation of silver are various, and are : —

The Patio process. The Barrel process.
The Hot process. The Pan process.
The Estufa process.

These will be separately considered.

Succeeding the description of the pan process, a number of examples of Gold Amalgamators are inserted which cannot readily be classed : acting by grinding, stirring, heat, lixiviation, panning, sluices, centrifugal action, electric action, and by mercurial fumes acting on a falling column of pulverized ore.

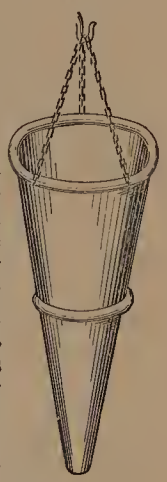
The Patio Process has long been in use in South America, and is now employed in Mexico, and now or lately in Nevada. It was invented by Medina in 1557. The materials necessary for the reduction of silver by this process are, magistral, common salt, and mercury. The magistral is made from copper pyrites reduced by stamps and arrastras to a fine powder. This is exposed to the air for some months and calcined in a furnace, a little salt being added. The effect is the production of a soluble sulphate of copper.

The silver ore is reduced by stamps and arrastras, or by the more modern forms of ore-grinders, to a fine powder which becomes a mud by the addition of water. The mud or "slimes" is then removed from the arrastra and deposited in walled receivers called "lameros," where it parts with a portion of its water and accumulates till it becomes sufficient to form a "torta." It is then spread to the thickness of about a foot, and after drying to a suitable consistence receives from three to five per cent of salt, which is tramped in by animals. The day after the incorporation of the salt, the magistral and mercury are added, being evenly spread over the "torta," as it is called, to the extent of one per cent of the matter in the heap. The proportion varies according to the richness of the magistral in the sulphate of copper. This is tramped in, and mercury is added ; three and one half to four pounds for every mark of silver supposed to be in the heap. (The mark is eight Spanish ounces of 443.8 gr. each.) This is trodden for four hours. Chemical action now commences, and the mass is carefully sampled from time to time to ascertain its condition and test the sufficiency of the proportion of magistral. If too little, more is added ; if too much, lime is added to prevent loss of mercury. The treading of the torta every alternate day expedites the action. The mules are hitched four abreast and blindfolded, being guided by a halter held by a man standing on the central platform.

The treading occupies about eight hours on each occasion, and in addition the mass is turned over twice a week with wooden shovels. Incorporation by a mortar-mill would probably be more thoroughly effective with a given amount of power.

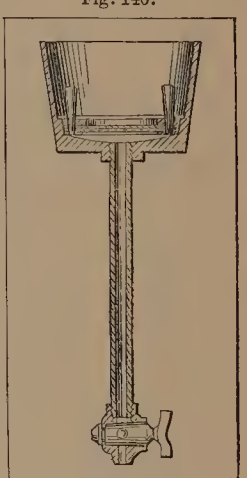
When the mercury has absorbed all the silver, the mass is washed by agitation in a series of tanks provided with rapidly revolving stirrers. The rate of motion of these is gradually reduced, and the metallic or heavier particles commence to sink. As soon as a test shows that the upper strata have but a trace of metal, a plug is withdrawn, which allows the earthy particles in suspension to be run off. The amalgam and heavier mineral particles are separated by a subsequent washing, and the amalgam placed in a stone trough, when it is treated with a further amount of mercury and subjected to frequent washings, which bring the amalgam into condition for the strainer, whose upper portion is of leather, and the lower closely woven canvas. A quantity of mercury strains through and is collected. The remaining amalgam is emptied on a leather-covered table and formed into bricks of a triangular shape, which are then ready for the process of retorting.

Fig. 139.



Strainer (from Tillmann).

Fig. 140.



Varney's Strainer.

Varney, March 18, 1852. This device is for expediting the straining of the amalgam. The tube, being closed at bottom, is filled with mercury. The amalgam is poured into the vessel, and the cock at the lower part of the tube is then opened. The quicksilver flows out, causing a Torricellian vacuum above it and beneath the strainer. The quicksilver in the amalgam is then forced through the strainer by the pressure of the atmosphere.

In some other strainers the vacuum is produced by mechanical means, such as an air-pump. In some others it is effected by the condensation of steam. If the pipe be long enough it may be obtained by a body of water, but the mercurial column, as in Varney's, brings the apparatus within much more compact limits.

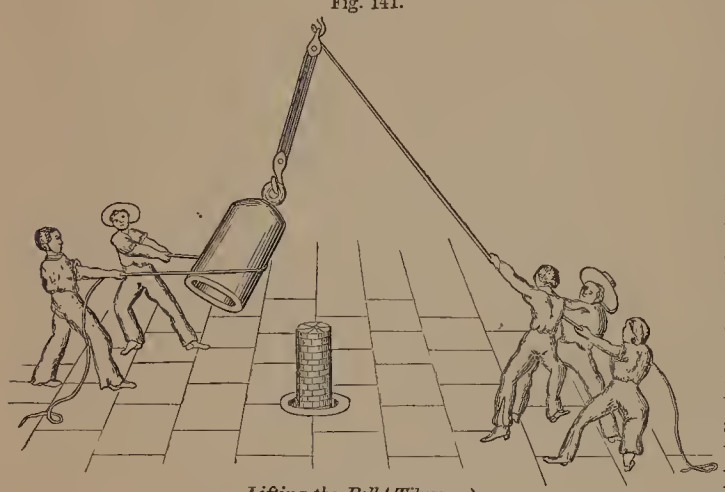
The operation

Fig 133.

The Patio Process.

by which the separation of mercury and silver is effected is conducted by the aid of a large iron or copper bell, which is placed over the amalgam, and around which is kindled a charcoal fire. A circular tank of masonry is constructed below the floor of the burning-house, through which a stream of water is constantly caused to flow; and in this is placed an iron tripod, covered by a round plate, having a hole in its center for the escape of mercury. On this plate are piled the bricks of

Fig. 141.



Lifting the Bell (*Tilmann*).

silver, to such a height as to reach to within a short distance of the top of the bell, which, when placed over them, leaves a space of about an inch between its sides and the column of amalgam. When thus arranged, the bell is lowered over it and the bottom secured, either by lute, or by a water-joint constantly supplied by means of a pipe. Adobes (unburnt bricks) are now built around the arrangement in the form of a hollow wall, leaving an annular space between them and the bell, of about eight inches in width. This is filled with charcoal, which is ignited, and as the temperature increases the mercury becomes volatilized, and passing into the chamber below the floor is condensed, collects in a liquid form, and escapes by an iron pipe into a proper receptacle. The fire is thus kept up during about fifteen hours, after which the apparatus is allowed to cool, and when sufficiently cold the bell is removed, either by a windlass or by means of simple blocks, as shown in the figure.

This silver, which is found to have assumed a porous structure and a beautiful frosted appearance, is called by the Mexicans *plata piña*, and is placed in leathern bags for removal to the smelting-house, where it is assayed and run into bars. The silver obtained by the patio process of amalgamation is in most cases very nearly pure, being generally above 990 fine; and in many cases, as at Guanaxuato, almost absolutely pure silver is obtained.

By the patio process, the amount of quicksilver lost varies from ten to twenty-four ounces per mark of silver, eight ounces (3.556.5 grains), and the time occupied is from fifteen to forty-five days.

The comminution of the ore in arrastras is not a necessary feature of the patio process, as in places where water-power is abundant the ore is reduced to a proper grade of fineness by stamps. A large number of patents for crushers and grinders have been patented in the United States, which are intended to act upon a constant, moderate supply of the broken ore, and reduce it by a succession of operations to the fineness required. See ORE-CRUSHERS, etc.

The nature of the chemical reactions of the *patio* process has been much misunderstood, but Sonnenschmid has given a solution which is now accepted. According to his theory, that portion of the silver which exists in the ores in a native state is alone capable of uniting directly with mercury; and if, in grinding with this metal any ores which do not contain silver in the metallic form, a small quantity of amalgam be obtained, it is produced by the action of some substance which in presence of mercury has the property of reducing the silver existing in a state of combination. These compounds, as well as the native metals, are susceptible of conversion into muriate of silver under the influence of muriatic acid liberated by the action of the sulphuric acid of the magistral on a solution of common salt. The muriate of silver thus formed may be destroyed by the addition of alkaline earths, but the silver will then be converted into an oxide which has no longer the property of forming an amalgam with mercury. Farther, that as certain metals have the peculiarity of separating others in a state of purity from the acids with which they are combined, mercury performs this part with regard to silver, by taking from it the muriatic acid, by which a portion of it is destroyed while the remainder forms an amalgam with the liberated silver. This reduction of the silver by the action of muriatic acid on metallic mercury, together with the direct action of the same on that metal, are the two causes occasioning the loss of quicksilver; the direct action of the acid manifesting itself whenever it becomes necessary to make a further addition of magistral. The mercury lost remains in the residue, either in combination with muriatic acid, or in the metallic state; the former representing the deficit known as *consumido* (consumed) and the latter forming that portion of the loss classed as *perdido* (lost).

The HOT PROCESS. This is employed in South America on a peculiar class of ores, containing a large proportion of native silver, or in which that metal occurs in the form of chloride, iodide, or bromide. The ore is roughly stamped, reduced to a certain grade in the arrastra, and washed on an inclined plane, by which the richer portions are condensed into an amount two per cent of the original bulk. The refuse may be graded and sorted, and the richer part subjected to a saving process. The finer portion is removed to a "cazo," a copper-bottomed vessel over a furnace. Water is added to make a liquid paste; when ebullition sets in salt to the amount of from five to ten per cent of the weight of the ore is added. The boiling mass is then stirred, and mercury added at intervals. This must not exceed twice the weight of the silver contained in the ore. This is determined by repeated tests. The operation completed, the liquid matter is removed and added to the ingredients of a "torta," while the solid portions are stored in wooden cisterns, and are subsequently washed and treated as described under the patio process.

An enlargement of the hot process consists of a larger copper vessel called a "fondon," in which blocks of copper are drawn around as the porphyry blocks of an arrastra. It is heated by a furnace below, as in the case of the "cazo." The charge of the latter

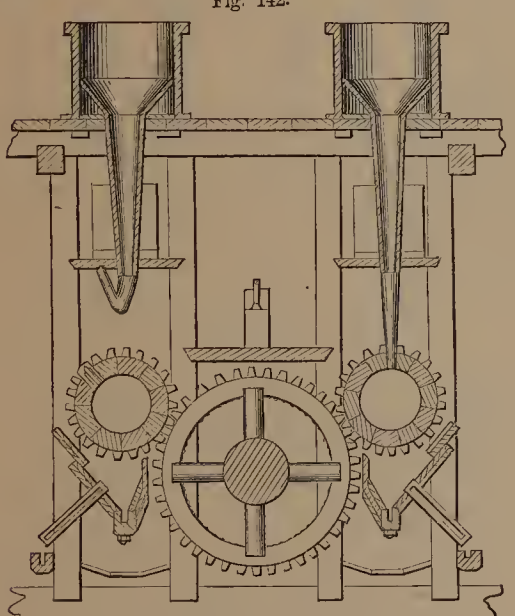
may be about 100 pounds, while that of the "fondon" is from 1,200 to 1,500 pounds, and the time for working them off is about six hours in each case. The sulphides are not reduced by this process, and are therefore added to the material of the patio, but do not require the addition of magistral, as they contain a sufficient amount of chloride of copper to convert the sulphides of silver into chloride; the copper is furnished by the attrition of the bottom of the vessel, which is kept clean, by the paddle in the case of the "cazo," and the copper block in the case of the "fondou." The proper proportion of the mercury and the mechanical action prevent the loss of mercury by adherence to the bottom of the pan.

The Estufa Process. In some of the colder and more humid districts of Mexico, a modification of the patio process has been employed. The ground ore, instead of being exposed in the open air on a paved courtyard, as in the ordinary patio process, is placed under a shed, and the usual method of patio amalgamation proceeded with, until the operation is about half completed. The ore is then removed into a chamber termed an *estufa* (stove), which has under it a fireplace six or eight feet long, so connected by side flues with small chimneys as to elevate the temperature of the room containing the ore. Here it is exposed to a gentle heat, and allowed to remain during two or three days, when it is again removed, and the reduction completed by the ordinary method of patio amalgamation.

By this process, the time required for the reduction of the ore is less than by the patio, and the yield of silver greater; the loss of mercury, on the other hand, is more considerable.

The Barrel Process. An apparatus of this description was in use at the latter part of the last century in Germany. It is described as "an apparatus consisting of eighteen small, cylindrical,

Fig. 142.

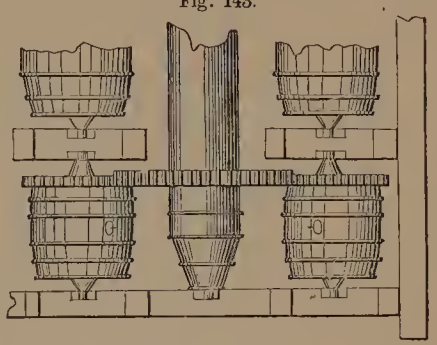


Freiberg Amalgamator (vertical section).

vertical vessels, arranged in a circle, in which the ores were mixed with mercury and constantly agitated by a vertical spindle in each tub, the spindles being worked by a large, horizontal spur-wheel placed in the center."

The amalgamating apparatus of Freiberg consisted of wooden casks arranged in rows and driven by pinions upon their shafts engaged by the teeth of a large spur-wheel. Each cask had a circular aperture, closed by a lid while revolving, and opened as required to receive a charge of roasted ore by a spout from the hopper above; or opened, when in the reverse position, to discharge its contents into the hopper below, after the argentiferous mer-

Fig. 143.



Freiberg Amalgamating Barrels (top view).

cury had been withdrawn at another opening, which at other times is closed by a plug. Each barrel is charged with 300 pounds of water and 1,000 pounds of finely ground ore; fragments of iron are added, the barrels closed and set in motion. When the material is reduced to a paste of the proper consistence, 500 pounds of mercury are added to each cask, and the closed barrels revolved for 16 hours at the uniform rate of 13 revolutions per minute. By the addition of water and subsequent revolution at a slower rate, the mercury is separated from the slimes and collects in a mass below the water, which holds the major part of the earthy particles in suspension, by the aid of moderate agitation. The mercury is then withdrawn by removing a plug and conducting the metal by a hose to a spout and receiver. The passage of earthy particles indicates the time to stop the flow. The plug is replaced, the lid withdrawn, and the muddy residuum discharged into troughs below. The chloride of silver contained in the roasted ores is, as in the Freiberg process, decomposed by agitation with iron fragments, the chloride combining with it to form protochloride of iron, while the reduced metallic silver becomes subsequently dissolved in mercury. The chlorides of lead and copper which may be present are reduced at the same time as the chloride of silver, and enter into the composition of the amalgam produced. The chlorides in the roasted ores are, by trituration with iron, reduced to the state of minimum chlorination, before the addition of the mercury, allowing the latter to act upon the silver immediately, and obviating the conversion of the mercury into calomel, which would not be again reduced and would prove a loss.

The muddy residuum, previously referred to, is re-treated, if sufficiently rich, by roasting, etc.

The amalgam obtained is filtered in the usual manner, and the remainder distilled to sublime the mercury. The metallic result is then refined.

The barrel process at the Ophir and other mines in Nevada is preceded by drying the ores in a kiln; dry stamping, screening through wire sieves, and roasting in reverberatory furnaces for from 4½ to 6 hours. About 5½ per cent of salt is added by portions in the furnace, the ore being stirred, and, before drawing, 1½ to 8 per cent of carbonate of soda is added to decompose the sulphates and chlorides of copper, zinc, etc., and prevent loss of quicksilver.

The roasted ore is then screened and the barrels

are charged with it. The charge of each barrel is 2,000 pounds of ore, 450 pounds of iron fragments, and water sufficient; they are then revolved for 3 hours. From 350 to 400 pounds of mercury are now added to each barrel, which are then revolved for 12 or 13 hours at the rate of 12 revolutions per minute. They are then filled up with water, again run for 2 hours, and the water drawn off. The amalgam is strained through a canvas bag to remove a portion of the quicksilver. The tailings are washed in a settler, and thence passed through a series of sluice-boxes into a flume about 600 feet long and 4 feet wide, provided with riffles.

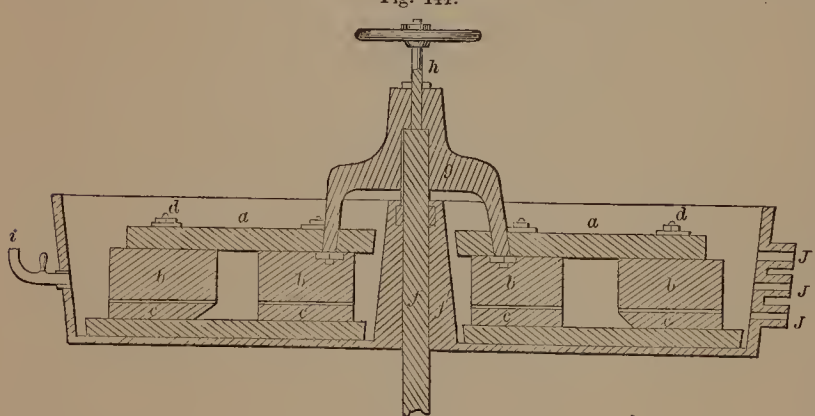
The amalgam is distilled in circular retorts.

The Pan Process. This process was designed especially for operating upon ores of poorer quality, dispensing with roasting incident to the barrel process and to the frequent manipulations and loss of time incident to the patio process. The ores of the mine being sorted into three grades of comparative richness, the first, assaying over $90 per ton, and containing a great deal of sulphur and refractory metals, is stamped dry and reserved for the barrel process; while the second, from $40 to $90 per ton, and the third, from $20 to $40 per ton, are stamped wet and treated by the pan process.

The crushed ore, after passing through the screen of the stamp-box, is conveyed to the settlers, passing from one to another till the water runs off clear.

The pans are very various in their construction, and a number of them will be shown in this section of the article on amalgamation. The common pan is a round, wooden, or cast-iron tub, six feet in diameter, two feet in depth, and with a flat bottom.

Fig. 144.

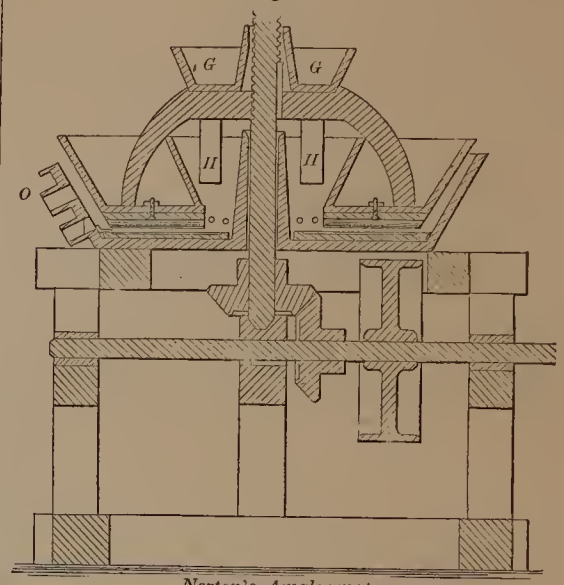


Common Amalgamating Pan.

A false bottom of 1½-inch iron is inserted into this, and a hollow pillar in the center admits the passage of an upright shaft which is generally worked by gearing beneath the pan, capable of communicating to it from fifteen to twenty revolutions per minute. It is sometimes geared much higher.

To the wooden arms *a* are attached the blocks *b*, also of wood, to which are fastened the iron shoes *c*, by means of the bolts *d*, passing up through the arms. Each shoe has also an iron pin, about an inch in length, which fits into the wooden block and keeps the iron-facing steadily in its place. On the shaft *f* passing through the central pillar *f'* is the yoke *g*, which, being fitted with a sliding key, can be raised by means of the screw *h*; and the ends of the yoke itself, being attached to the wooden cross-arms, the mullers will be raised at the same time. Steam is introduced into the pan by the pipe *i*, the discharge being effected by means of the apertures *J*. The false bottom is made one inch less in diameter than the bottom of the pan itself, and has an aperture in the center an inch larger in diameter than the base of the pillar, in which the vertical shaft works. To fasten the bottom in its

Fig. 145.



Norton's Amalgamator.

place, and prevent the mercury from finding its way under it, strips of cloth, about two inches in width, are lapped around the edge of the false bottom, as well as applied against the sides of the pan.

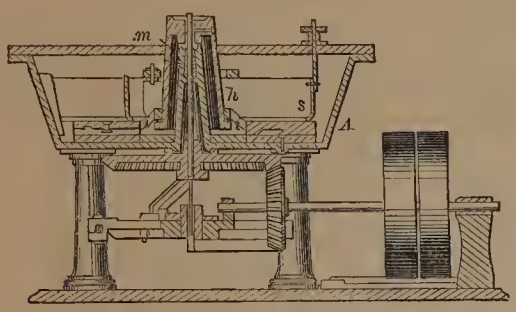
A little iron cement is then poured in, and the bottom secured in its place by means of well-dried wooden wedges tightly driven between the two layers of cloth. These wedges, which are driven quite close to each other, must be somewhat shorter than the thickness of the false bottom, thus leaving a space above them which is subsequently covered with a paste of iron cement, that is allowed to set before using the apparatus. About one-horse power is required to work this pan, which will amalgamate from one and a half to two tons of ore in the course of twenty-four hours.

Norton, September 18, 1860. The annular revolving funnel *G* distributes the powdered material by pipes *H* to the space near the central pillar through which the vertical shaft passes. The grooves in the faces of the muller and bed-plate are arranged in curved lines, so that the material is fed from the center towards the circumference before it reaches the discharge-openings *O*. Projecting points, as the muller and bed-plates, act upon the fed material, and force it from the center as it passes from the pipes *H* into the mill, giving it an eccentric motion, and causing it to come repeatedly under the triturating operation. The balance-rynd with its mullers is adjustable vertically on the shaft to regulate the proximity of the grinding surfaces.

Varney, December 16, 1862, and July 12, 1864.

A stationary bed-plate is attached to the floor of the pan *A*, and has radial grooves which are filled with wood. The rotary-disk has radial, open grooves, formed by the intervals between the sectional pieces which are attached to the face of the disk and form the mullers. The disk itself is an annulus, and is connected by arms *i* with the outer tube *h*, which forms the balance-rynd and rests upon the central pillar *m*, being rotated by the central shaft which is driven by gearing below. The opening in the

Fig. 146.



Varney's Amalgamating Pan.

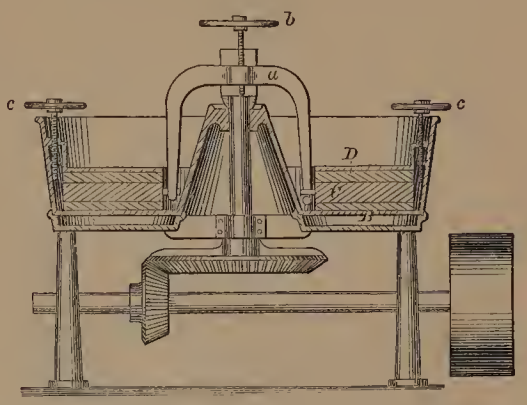
center of the rotating disk is considerably larger than the tube *h*, so as to leave a hiatus in which the material collects. The action is such that the ore will pass outward from this central space between the faces of the upper and lower mullers, and arriving at the peripheral opening is drawn in by spiral scrapers *s*, which are supported from above and return the pulp over the top of the upper muller, to the central space, for a repetition of the operation. The shoes are renewable, and are secured to the disk by rivets which are cast in them. The operation of this apparatus is as follows: The space about the periphery of the lower muller is filled with quicksilver, and the pan nearly filled with pulp of the proper consistency to flow easily; the shaft is now made to revolve at a proper speed, from sixty to eighty revolutions per minute, by which the upper muller is rotated. The pulp between the mullers, by means of the centrifugal force developed, is made to pass out through the radial chanuels between the dies, as well as between the grinding surfaces of the upper and lower mullers; also into and over the quicksilver, thereby causing amalgamation.

The outward motion of the pulp has the effect of keeping the quicksilver entirely away from the grinding surface, thereby obviating what has often proved a very serious difficulty, namely, the grindiug of the mercury.

The rotation of the upper muller causes the pulp in the pan to revolve with it. This current is met by the cuneiform projections and curved plates, and thereby turned toward the central opening in the upper muller. The radial slots between the shoes, running from the central opening to the outward one, allow currents of considerable size to pass with great velocity; and the pulp filling these slots, being continually thrown outwardly, tends to produce a vacuum. By this the pulp in the body of the pan is set in motion, causing a rapid and abundant flow downward at the center, and upward along the inner surface of the pan. The pulp is thus made to circulate until the complete pulverization of the quartz and amalgamation of the metals have taken place.

Coleman, August 18, 1863. The muller of this pan is driven, as are the preceding, by the central vertical shaft which is projected up the central cavity of the annular pan. The shaft supports a balance-rynd *a*, to whose ends are attached the muller *C*, which revolves between two plates *B D*, respectively below and above. The muller *C* has corrugations on its upper and lower surfaces, as have also

Fig. 147.

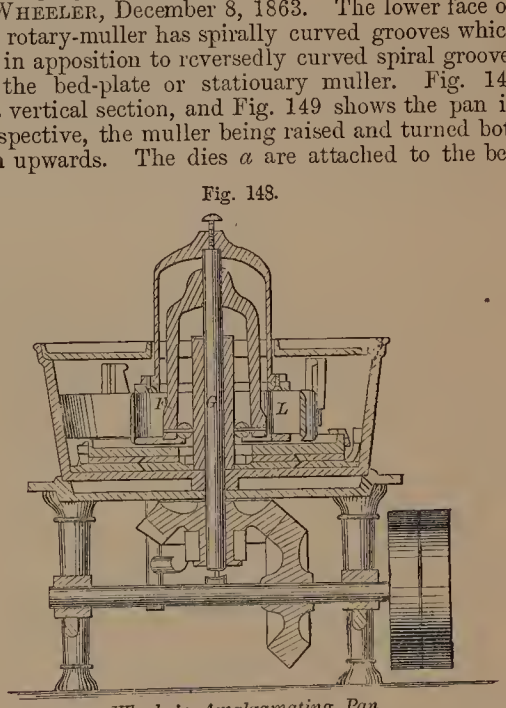


Coleman's Amalgamator.

the surfaces with which it comes in contact. The vertical position of the rotary-wheel or muller is adjusted by the central wheel *b*, and that of the upper plate *D* by the set screws *c*, which are four in number and set at opposite points. By this double adjustment the spaces between the grinding surfaces are gradually approached, as the pulp becomes finer in the progress of the work.

Wheeler, December 8, 1863. The lower face of the rotary-muller has spirally curved grooves which act in apposition to reversedly curved spiral grooves on the bed-plate or statiouary muller. Fig. 148 is a vertical section, and Fig. 149 shows the pan in perspective, the muller being raised and turned bottom upwards. The dies *a* are attached to the bed

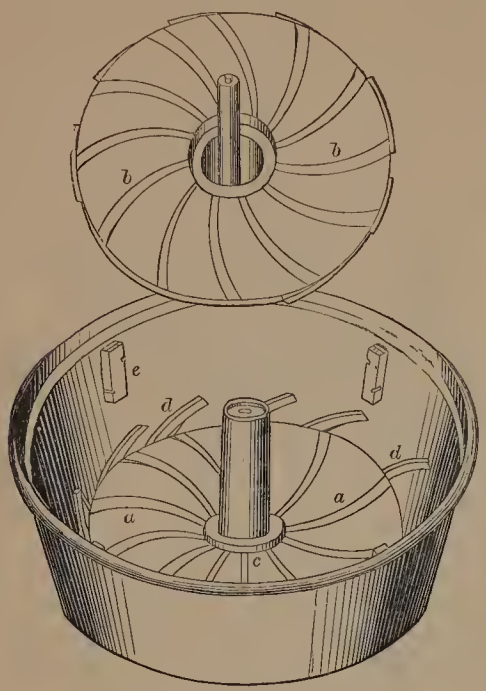
Fig. 148.



Wheeler's Amalgamating Pan.

of the pan, and the shoes *b* to the rotary-disk; this is attached to the hollow cone *F* (see Fig. 148), which is connected to the vertical shaft *G*, and that to gearing beneath the pan. The dies *a* are kept in their places by the central ring *c*, and on the sides by the inclined ledges *d*, under which their edges are wedged. Spiral ribs are fixed on the periphery of the rotary-muller, and act in concert with reversedly spiral ribs *d* attached to the side of the pan to create an upward current in the pulp, which is then swept toward the center again by curved guide-plates attached to the blocks *e* on the

Fig. 149.

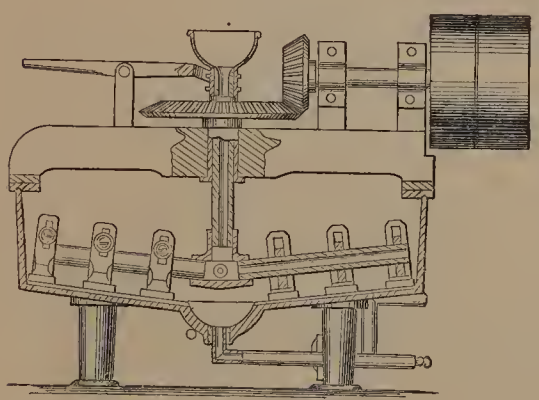


Wheeler's Amalgamator.

inside of the pan. This pan is 4 feet in diameter at the bottom, is said to require from 2½ to 3 horse power to run it effectively, and is geared for sixty revolutions per minute. The muller is connected to its driver by a universal joint. The pan has a double bottom, and is heated by steam admitted to the space thus formed.

WHEELER, July 14, 1863. This machine is constructed for saving the mercury from the pulp or

Fig. 150.

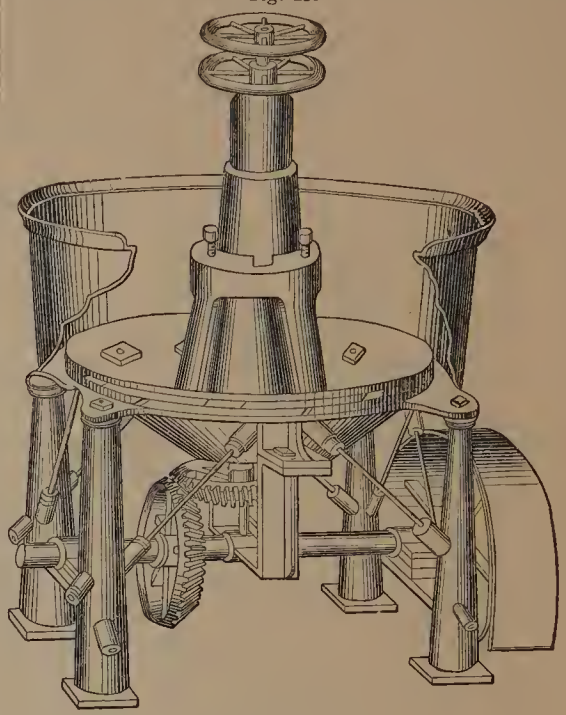


Wheeler's Separator.

waste matter which escapes from the ordinary amalgamators, and consists of a tub with concave bottom and a central depression, in which is a vertical tubular rotary-shaft having arms on which pads are placed, which rub on the bottom and collect the particles of mercury which run down into the central chamber; water is supplied through the hollow shaft, which may be decanted off by a siphon or cocks, and the quicksilver drawn off by the lower tube connected with the gathering-chamber.

HEPBURN AND PETERSON, April 19, 1864. This pan differs mainly from the foregoing in the shape of the bottom, which is inclined towards the center, or shaped like an inverted cone. The shoes are bolted to the face of the conical muller in such a

Fig. 151.



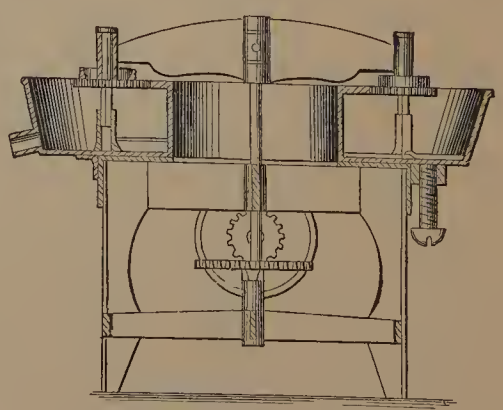
Amalgamating Pan.

way as to leave intervals which form spiral grooves. The dies of the bed are fastened to the pan bottom, and have a similar arrangement, forming spiral conductors whereby the pulp is led towards the periphery; ascending against the sides of the pan, it descends by gravitation over the upper surface of the rotary-muller, is collected at the center, and again driven outwards. A constant and active circulation is thus established without the aid of the curved scrapers shown in some of the preceding examples. The charge for this pan is about 1,400 pounds, and the time requisite for working it from two to four hours, according to circumstances. The rate of running is from fifty to sixty revolutions per minute. The muller is supported upon a balance-rynd, as in the previous examples, and is adjustable vertically by hand-wheels, a thimble, and a tubular screw.

The following two are examples of planetary motion.

HANSBROW, October 27, 1863. The pan has the

Fig. 152.



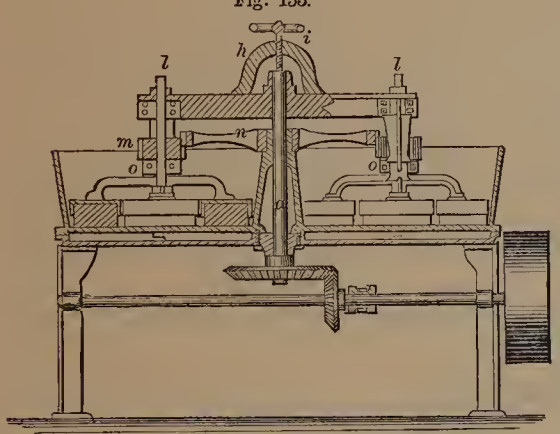
Hansbrow's Amalgamating Pan.

same features as the foregoing, but the action of the mullers is different. The vertical shaft is driven by gearing below, and passes up through a central cavity in the annular pan. On the summit of the shaft is an arm in which are journaled the vertical shafts of the dependent mullers. Each of the latter shafts has a pinion which engages a circular stationary rack on the inner edge of the pan, so that, as the mullers revolve around the main shaft, they have also a rotary motion on their own axes. They thus acquire what is called a planetary motion, rotating as they revolve.

The grinding effect of this motion is very satisfactory, and the mullers wear nearly evenly. The effect of a simply revolving muller is to wear the fastest nearer the periphery, as that passes over a greater frictional surface in describing a larger circle. This difficulty is, however, met by Dodge's patent, described elsewhere in this article.

KENYON, July 19, 1864. This, like the one immediately preceding, consists of a circular pan, through the center of which passes a vertical shaft. To the upper end of the shaft is attached a cross-head fitted with a yoke, through which a screw passes and rests upon the end of the shaft. At the ends of the cross-head, bows are attached carrying the vertical shafts, upon which are pinions gearing into a stationary wheel. At the end of each shaft are placed arms, and at their ends are irons for receiving the mullers. The mullers have a quadrangular arrangement at the ends of arms *o*, similarly disposed and radiating from the shafts *l*. As in the preceding example, they have rotation on their own axes by the engagement of their respective pinions *m* with the stationary wheel *n*,

Fig. 153.



Kenyon's Amalgamating Pan.

and have also a revolution in the track formed by the annular pan, owing to the rotation of the shaft *a* and cross-head. The adjustment of pressure of the mullers on the face of the pan is obtained by the set-screw *i*, which passes through the yoke *h* and rests on the shaft *a*. Each muller receives a cycloidal movement.

The process of working in pans is not *merely* a mechanical trituration of the material, and an exposure of it to the contact of mercury. These, of course, are necessary incidents, but the chemical reactions of the constituents are in many respects similar to those described under the patio process and the barrel process of Freiburg and Nevada. The energy of the treatment, however, has the effect of expediting the decomposition of the material and the combination of the precious metals with the mercury.

In operating, the charge having been placed in the pan, the muller is put in motion, and gradually lowered as the material becomes pulverized. Steam is then injected into the mass, raising its temperature to 200° Fahr., care being taken to retain a proper consistence. The muller being slightly raised, quicksilver is added in a shower from a canvas bag, to the extent of from ten to fifteen per cent of the material under treatment; sulphate of copper and sulphuric acid are also added in small quantities; also salt in some cases. Many suggestions of materials to be added are rife among the miners, but appear to be empiric in their character, and not derived from critical chemical consideration of the reactions taking place or required. The running of the pan to complete the amalgamation is continued for three or four hours. The pulp is then thinned so as to flow out of an opening in the bottom of the pan, and is conducted to the separator; or it may be thinned and settled in the pan, reducing the pulp so as to allow the heavier portions to settle, and decanting the mere liquid either by siphon or by opening the cocks on the side of the pan, beginning at the uppermost and proceeding downwards in order, as the condition of the settling renders advisable. Several of the examples show these cocks, but others are so arranged that the pan will tip on its hinges and discharge its contents. In the larger pans, where it is desired to make the work as continuous as may be, the whole charge of the pan is drained off and subjected in a separator to a second process of dividing the earthy particles from the metal, in order that the pan may be expeditiously recharged and proceed with its work.

One of these separators is shown in this article, but the common pan (also shown) is frequently used.

In the separator the pulp is mixed with a large quantity of water, and a regular steady supply kept up, so as to carry off the lighter particles of earthy matter, at first from holes in the upper part of the pan; but as the separation proceeds the discharging-point is gradually lowered, until eventually nothing but the heavier pyrites and liquid amalgam is left. The amalgam is drawn off from the bottom, and the pyrites then scooped out, and after being further washed in another separating-pan, to remove the last traces of amalgam, it is reserved for final treatment by calcination and reduction in barrels. The amalgam is now carefully washed in clean water, dried with flannels, and finally removed to the amalgam-room, where it is strained through thick conical bags of canvas twelve inches in diameter at the larger end, and two feet in length.

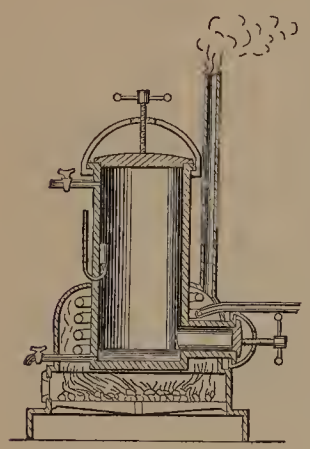
After the bags have drained for some time, they are beaten with a round stick to cause a further quantity of the mercury to run off. The hard, dry amalgam is finally removed from the bags and weighed into store.

The mercury run off from the bags is technically known as "charged quicksilver," and after being mixed with retorted mercury is returned to the pan-room for farther use. Charged quicksilver is preferred to the pure metal, as with it amalgamation is found to proceed more rapidly.

AMALGAMATION OF ROASTED ORES. In some of the mining districts of Nevada, and particularly in the neighborhood of Austin, where the ores consist of various compound sulphides of silver, containing a considerable amount of antimony, the ordinary pan process, as practised at Virginia City, cannot be advantageously employed. The ores from this part of the State consequently require roasting before being subjected to amalgamation, and then, when

worked in the pans, afford better results than those obtained from the ores of the Comstock vein treated in their raw state. Each battery of five stampers will crush (dry) four tons of ore daily, through a wire-gauze screen of forty holes per linear inch. One thousand pounds of this crushed ore are roasted with eight per cent of common salt ; the time occupied in the furnace by each charge being, on an average, six hours. Pans are most commonly employed, and are charged with from eight hundred to one thousand pounds of roasted ore, which occupies five hours in working. A mill of ten stampers, with all the necessary furnaces, pans, and appliances, will treat eight tons of ore in the course of twenty-four hours, with a total consumption of about ten cords of wood. It is stated that the loss of silver in the neighborhood of Austin, where the ores contain little or no gold, seldom exceeds seven per cent of the assay value.

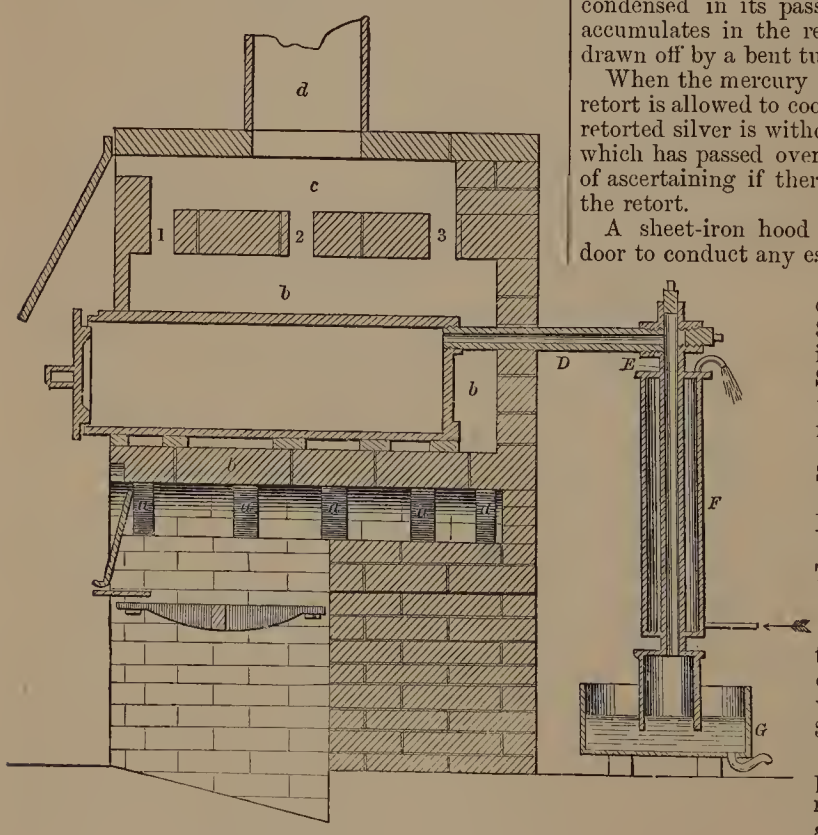
Fig. 154.



Spencer's Amalgamator.

Spencer, November 22, 1864. The treatment is designed to desulphurize the ore simultaneously with its exposure to the mercurial fumes. The ore, finely pulverized, is placed in a vessel with a small amount of mercury, and the vessel then strongly closed. Heat is then applied, so as to vaporize the mercury. After this treatment the ore is placed in any suitable amalgamating vessel, and washed and treated in the usual way.

Fig. 155.



Amalgam Retort.

Retorting. The silver or gold amalgam is treated in the assay-office, and the mercury separated by distillation in a cast-iron retort with a luted cover, placed upon an arch of fire-brick, and having another arch above it, being, with the exception of one end, enclosed within a chamber. Fig. 155 shows the arrangement of the retort and chamber. The charge of amalgam is weighed and placed in a semicircular tray divided by a transverse partition. Before being put in the tray the amalgam is coated with milk of lime or a thin wash of clay, a sheet of paper being sometimes placed under it ; by these means the amalgam is prevented from adhering to the tray. The tray being placed in the retort, the cover is closed and carefully luted with a thin paste of clay and wood-ashes. The fire is then lighted in the furnace, and the heat very gradually raised until the retort is at a bright red heat. The flame and smoke from the furnace pass through the flues *a a*, etc., up into the chamber *b* and around the retort, the smoke, etc., ascending into the chimney *d* through the flues 1, 2, 3, etc., and the chamber *c*, the draft being regulated by dampers attached to these flues. A horizontal pipe *D* is fitted into the inner end of the retort, and is so connected to the vertical downcast pipe *E* that they admit of being readily separated for cleaning ; the pipe *E* terminates in a chamber open at the bottom, and immersed sufficiently deep in a tank of water to keep it air-tight, but not to allow of water being drawn up into the heated retort, and passes through an outer pipe *F*, in which a current of water circulates from below upward, having its exit by a pipe at the top. As the retort becomes heated the volatilized mercury passes through the pipes *D* and *E*, being condensed in its passage through the latter, and accumulates in the reservoir *G*, from whence it is drawn off by a bent tube.

When the mercury has ceased to distil over, the retort is allowed to cool gradually, and when cold the retorted silver is withdrawn, and it and the mercury which has passed over are weighed for the purpose of ascertaining if there has been any leakage from the retort.

A sheet-iron hood is placed over the furnace-door to conduct any escaping vapors into the flues.

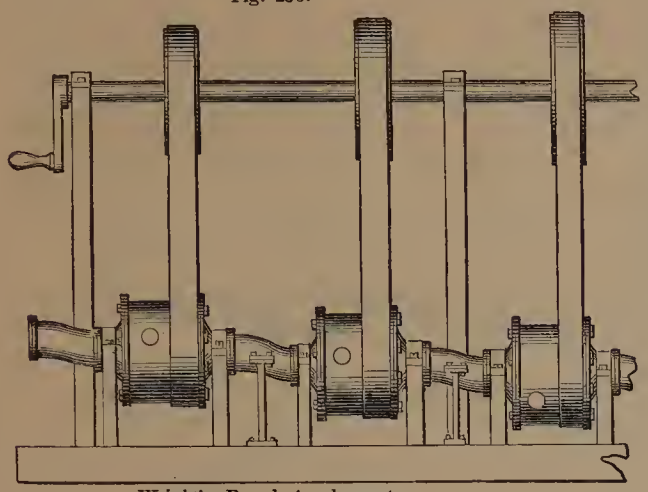
According to Phillips, the cost of working from $45 to $50 ores by the pan process is, in those portions of the State of Nevada in which water-power can be obtained, nearly as follows : —

	Per ton.
Stamping wet, through No. 6 screens . .	$1.50
Milling, including, the loss of mercury, etc.	5.00
Total cost including wear and tear . .	$6.50

The loss of mercury amounts to from 1¼ to 1½ pounds for each ton of ore containing silver to the amount of from $35 to $50 per ton.

The Barrel Process as applied to gold is exemplified in many forms. In Fig. 156 the gold is amalgamated in hollow revolving cylinders upon hori-

Fig. 156.

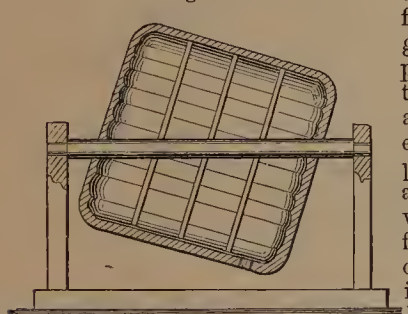


Wright's Barrel Amalgamator.

zontal axes, the trunnions being hollow to admit the pulverized ore from one cylinder into another. The cylinders are connected by flanges or S-pipes with grooves turned into the axes or trunnions, and rings are fitted into the grooves and covered by the flanges; the whole are so connected as to make them water or steam tight, and so arranged as to give a fall of about six inches to each cylinder. The cylinders contain rollers, knives, burnishers, and other analogous arrangements to produce friction, scour the ore, and assist the contact with the quicksilver.

HEATH, February 17, 1863. This machine consists of a cylinder which rotates upon an axis diagonal with the true cylindrical axis, and is formed with a corrugated interior surface, the corrugations running parallel with the true axis and across the end; it is also provided with annular ribs, which project from the inside of the cylinder in a plane parallel to the heads and at right angles to the axis of the cylinder. The effect of the obliquity of the axis of rotation is to make the contents slide and roll as the machine is rotated. A lid admits to the interior, and the latter is also entered by a pipe.

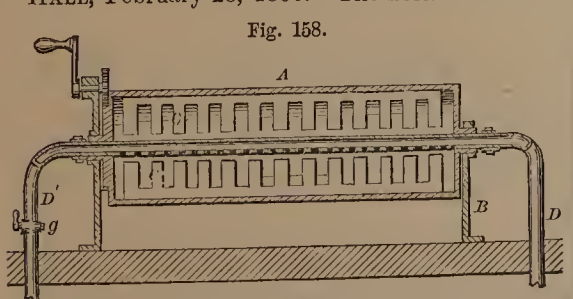
Fig. 157.



Heath's Amalgamator.

HALL, February 28, 1866. The horizontal rotating cylinder *A* has internal lifters *c c*, which raise and turn over the pulverized quartz contained therein. The central pipe is stationary, and the cylinder turns thereon. The pipe *D* connects with a retort, and conducts therefrom the mercurial fumes which pass into the cylinder through perforations in the lower part of the pipe. The end *D'* of the pipe dips into a vessel of water that condenses any mercurial vapor which passes over when the stopcock *g* is opened. The cock regulates the pressure of vapor in the cylinder, which has a door by which it is charged and uncharged.

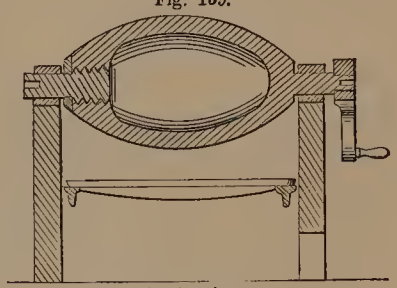
Fig. 158.



Hall's Cylinder Amalgamator.

STAATS, March 13, 1866. The ore is placed in a closed vessel in company with an allowance of quicksilver, and is then rotated on its horizontal axis above the fire in the furnace. The fumes eliminated by the heat from the mercury penetrate the material as it is agitated by the rotation of the vessel.

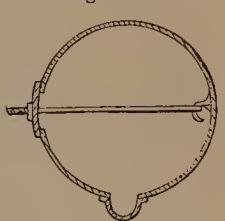
Fig. 159.



Staats's Amalgamator.

STURGES, September 18, 1866. The barrel amalgamator has a pocket to retain the mercury and distribute it to the ore as the barrel revolves. The cylinder is stayed by diametric bolts.

Fig. 160.



Sturges's Amalgamator.

GOLD. *The Battery Process.* In the amalgamation of gold ores the auriferous quartz is broken by a crusher into pieces of about a pound weight, and is then stamped. For wet crushing, stamps are used weighing from five to nine hundred pounds including the stem, and are driven at the rate of seventy blows per minute with a fall of from six to nine inches. They are fed by an attendant whose duty it is to regulate the supply of ore, water, and quicksilver, when that metal is used in the battery for amalgamating the free gold present.

Amalgamation in the battery requires careful attention, principally to avoid the too rapid addition of quicksilver, which should be supplied in very small quantities only.

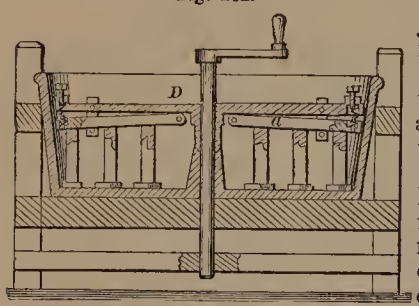
To amalgamate the free gold in a battery, the quantity of quicksilver to be used is about one ounce weight to each ounce of gold present; this is sufficient to collect the gold and form a dry amalgam. If, therefore, a mill will stamp twenty-four tons of ore in twenty-four hours, and the ore contain an ounce of gold per ton, it will be necessary to put into the battery an ounce of quicksilver every hour. When, in addition to gold, the rock under treatment contains metallic silver, the amount of mercury added must be proportionably increased. More than eighty per cent of the assay value of the gold in the ore may by careful manipulation be thus obtained. The gold amalgam accumulates in the corners and crevices of the battery box, between the dies, on the breast of the mortar, over which the crushed ore is washed into the settling-cisterns, and is even found in considerable quantities adhering to the stamp-shoes. The amalgam thus obtained is very hard and heavy, and is commonly so rich in

gold as to be worth as much as ten dollars per ounce. The crushed ore is taken off from the mortar by a supply of water, equal to the run of ¾-inch pipe to each set of five stamps, passing through screens in the back and front of the box. These screens are made of thin Russia iron perforated with holes punched by sewing-needles.

Auriferous sand is treated in divers amalgamating machines; it being already in a comminuted state, it is not necessary to put it through the battery.

Dodge, May 3, 1864. This invention relates to an arrangement of the rotary-shoes of the machine, whereby the outer ones, which are subjected to the most wear in consequence of having the greatest speed, may always be adjusted so as to run in contact with the bottom of the pan, and the wear thereby compensated for. In the ordinary amalgamating machines the outer shoes, in consequence of being subjected to more wear than the inner ones, soon become comparatively useless.

Fig. 161.



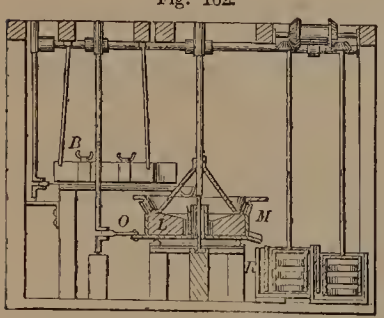
Dodge's Amalgamator.

The adjustable shoes are attached to supplemental bars, which are hinged to the radial arms *D*, and are also connected thereto by springs which permit adjustment of the pressure.

Miscellaneous Machines. The following are diverse in their construction from those previously cited, and are not strictly referable to either of the classes, while partaking of some of the features of the "pan" and the "barrel" process.

Charles, September 25, 1866. The inclined panners *B* are suspended by rods from the frame, and are oscillated by machinery. They discharge into a trough which leads the ore-dust and water to a grinding-pan. The ore and water enter the eye of the runner, and pass between it and the bed-plate to the periphery, at which they are discharged by a spout to a series of amalgamating-boxes, each of which consists of a case *R* containing a series of copper pans placed in vertical series. The upper muller *L* has a rotary motion, and the lower one an oscillation, derived from the crank and pitman *O*. The shell *M*, whose floor forms the lower muller, travels on rollers as it oscillates.

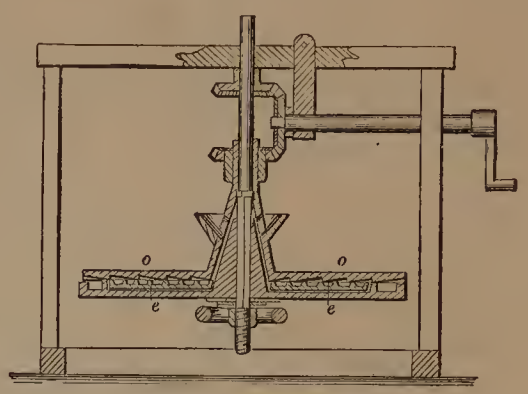
Fig. 162.



Charles's Amalgamator.

Brock, May 1, 1860. The upper surface of the revolving disk *e* is divided into a number of receptacles, and the lower surface of the disk above it is ribbed. The respective disks revolve in different directions. The receptacles are filled with mercury, and the action of the upper plate *o* is to feed the pulverized ore from the center continually towards the periphery, its gravity keeping it as a film in contact with the mercury upon which it floats and travels. The disks are rotated by the engagement of their respective pinions with bevel-wheels on the driving-shaft.

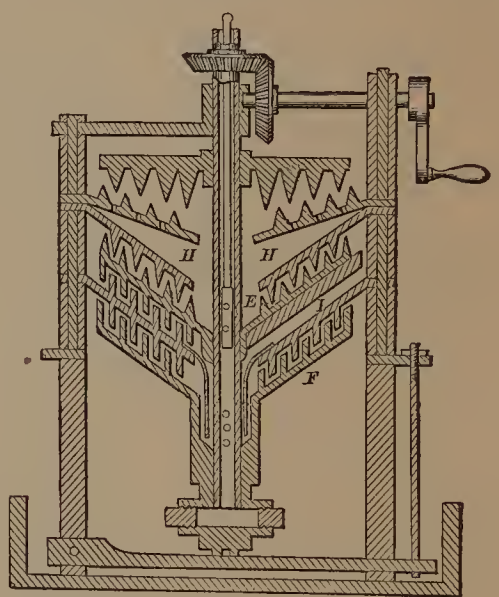
Fig. 163.



Brock's Amalgamator.

Battels, January 6, 1863. This apparatus consists of a series of toothed annular plates *H I*, secured to the casing of the machine and inclining down towards the center, and a corresponding number of revolving toothed plates *E F*, mounted on a vertical shaft, forming basins in which the mercury is contained and occupying the spaces between the stationary plates. The material to be washed or scoured, falling on the outer part of the upper stationary plate, is acted on by the teeth of the revolving plate above, and passes inward by its own gravity until it falls on the center of the revolving plate *E* next below, whence it is carried outward by centrifugal action until it falls on the stationary plate *I* next below, and so on to any extent required.

Fig. 164.

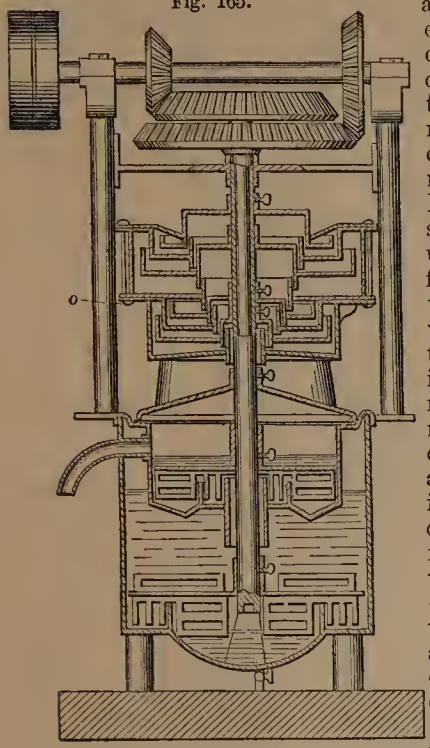


Battels's Washer and Amalgamator.

The vertical shaft is stepped in a lighter-bar, which is raised or lowered to adjust the proximity of the teeth on the rotating disks to those on the stationary ones. The amalgamated metals collect in the central pockets, and are removed therefrom as they accumulate.

Pietsch, May 3, 1864. The upper part of the

Fig. 165.

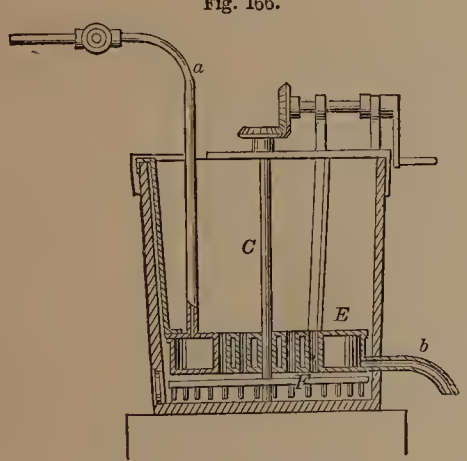


Pietsch's Separator and Amalgamator.

apparatus consists of a double series of pans, the alternate ones revolving in different directions. Each is smooth on its upper surface, but has teeth below, which agitate the material in the pan next beneath. The ore and water are compelled into a tortuous course, falling over the edge of each pan in the series, and being caught by the one beneath. After reaching the point *o*, the ore is led in again to the center, and the action is repeated. The heavy particles accumulate at the bottoms of the pans, and are thence removed to the amalgamators below, where they are agitated by stirrers above and in contact with the mercury which occupies the depressions in the bottoms of the pans; the pans communicate by a central channel.

KENDRICK, May 29, 1866. The agitator *F* operates in the bottom of the tank, being driven by the vertical shaft *C* and the gearing above. The box *E* occupies a position near the bottom of the tank, and is heated by steam introduced by the pipe *a*. *b* is the discharge-pipe for the water of condensation.

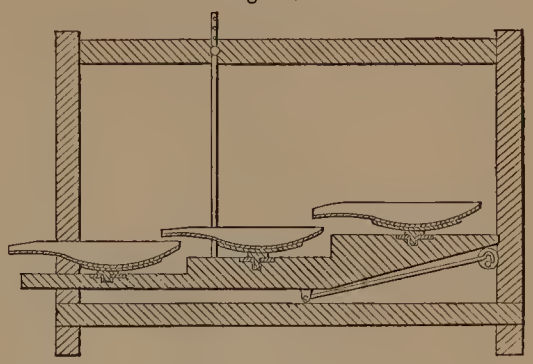
Fig. 166.



Kendrick's Amalgamator.

PECK, February 21, 1865. The pans are arranged in successive order upon steps on the swinging platform. Each pan empties into the one next below it in the series. The belly of each pan has some mercury, and the combined vertical, longitudinal, and partial rotary movement is to settle the heavier matters to the bottoms of the pans and shift the lighter material to the pans next below. The peculiar complex motion of the pans is intended to imitate the hand motion in panning.

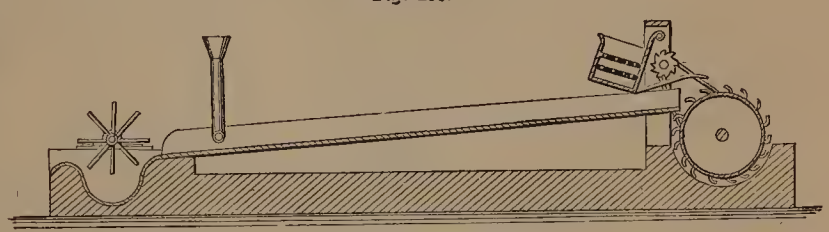
Fig. 167.



Peck's Amalgamator.

PARTZ, July 14, 1863. The powdered ore is distributed in a dry state over the current of mercury flowing upon the inclined surface of the metallic trough. The surface of the latter is amalgamated with mercury, and that which flows to the lower end is re-elevated and again distributed upon the trough. A current of water and an agitator-wheel assist in removing the tailings which reach the receptacle at the lower end of the trough.

Fig. 168.

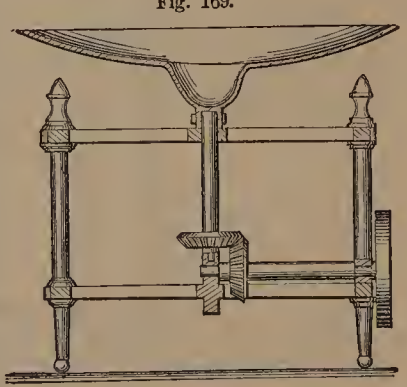


Partz's Amalgamator.

HILL, January 1, 1861. This operates by centrifugal action. The rotating basin has a central depression to contain the mercury, and its surfaces are amalgamated to cause adhesion of the amalgam, as it is formed by the contact of the mercury with the precious metals in the pulverized ore. The water, quartz, and lighter impurities are expelled over the edge of the basin by centrifugal force, while the heavier, valuable results settle into the central pocket.

GARDINER, October 4, 1864, subjects the finely pulverized dust of ores, in connection with mercury, to a powerful agitation and centrifugal action, by placing them in a partially covered revolving pan; the form of the rim prevents the loss of the

Fig. 169.

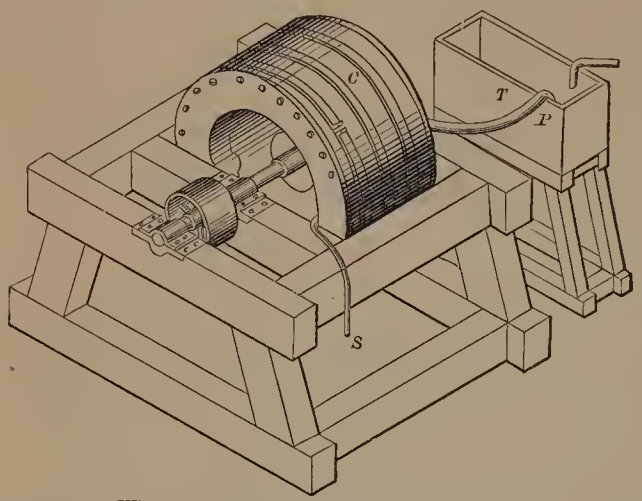


Hill's Amalgamator.

metallic portions, while the lighter impurities are ejected over the edge of the pan, into which a stream of water constantly flows.

WHELPLEY AND STORER, September 11, 1866.

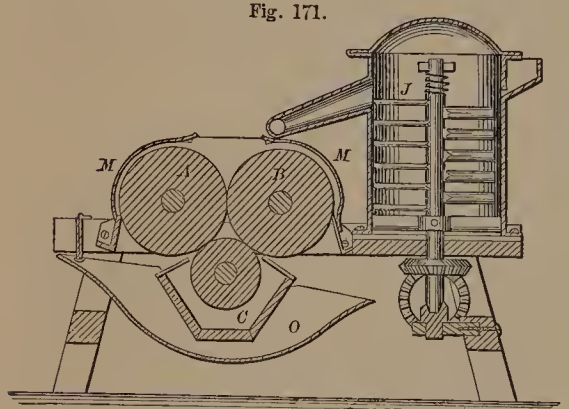
Fig. 170.



Whelpley and Storer's Amalgamator.

The outer cylinder is supported on shaft attached by a hub to an internal plate. The interior of the

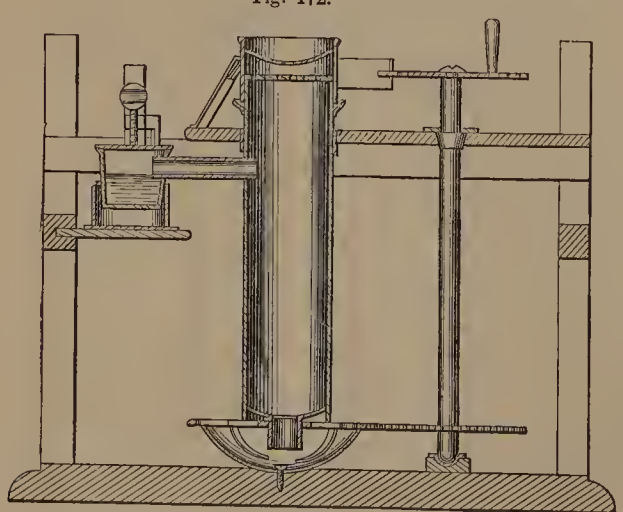
Fig. 171.



Phelps's Amalgamator.

cylinder is coated with mercury; the pulp, being introduced during rapid rotation, is spread over the

Fig. 172.

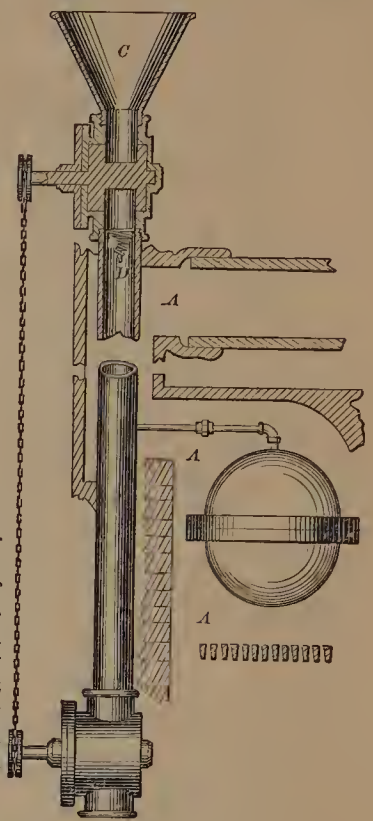


Adams and Worthington's Amalgamator.

interior surface by the centrifugal force, and the metallic particles are seized and amalgamated by the mercury.

The supply is derived from the tank *T* by pipe *P*,

Fig. 173.



Day's Amalgamator.

and the tailings discharged by pipe *S*.

PHELPS, October 18, 1846. The lower roller revolves in a trough of mercury *C*, and distributes it upon the upper rollers *A B*, which are brought into an electric circuit to increase their attractive energy in accumulating the adhering amalgam, which is subsequently scraped off and falls into the receiver *O*. The pulp is supplied to the upper rolls through a spout proceeding from a tank *J*. The jackets hold the ores to the rollers for a specific portion of their revolution.

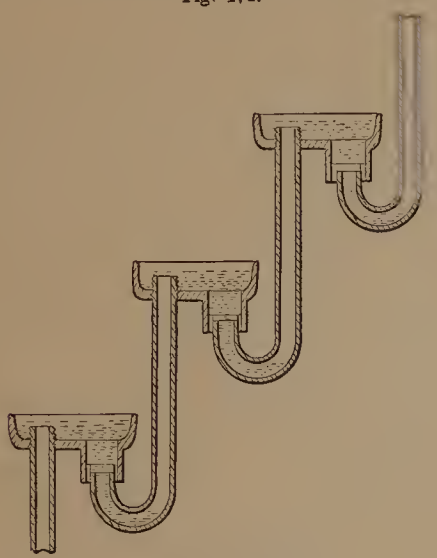
ADAMS AND WORTHINGTON, February 12, 1864. This invention consists in pulverizing the quartz or metalliferous substances containing precious metals to an impalpable powder, and precipitating and discharging this dust either in a calcined or otherwise prepared condition, in order to isolate the metallic particles from their sulphurous or other foreign combinations, into an atmosphere of hot vapor of quicksilver. On the upper end of a vertical stationary cylinder is fitted a short cylinder, which is made to turn therein, the same being provided with a screen or hopper. Below the stationary cylinder is a pan in which stirrers are made to operate. Communicating with the main cylinder, by means of a tube placed a little below the screen in the upper cylinder, is a furnace or still for distilling the quicksilver which falls with the calcined particles of ore through the stationary cylinder.

DAY, September 26, 1865. The retort is set in a furnace *A*, and delivers fumes of mercury into the vertical tube *D*. The pulverized ore from the hopper *C* is delivered by a feed-wheel in graduated quantities, and falls the length of the tube, at the lower end of which it is delivered by a discharge-wheel, so that the fumes may not escape. The length of the tube may be such as is found sufficient for the purpose.

and the respective wheels *E F* are connected by a driving-chain. The particles of the precious metals combine, in falling, with the mercurial fumes with which the tube is charged.

Hall, December 27, 1864. This invention consists of a series of curved pipes connected with quicksilver basins in such a manner that the lower end of the upper pipe and the upper end of the second pipe will enter the bottom of the first basin, the end of the other pipe extending slightly above

Fig. 174.



Hall's Amalgamator.

the bottom of the vessel. The lower end of the latter pipe and the upper end of the pipe *A* enter the bottom of the pan, and so on throughout the whole series.

He claims an apparatus for separating gold from foreign substances, composed of a series of bent pipes or tubes combined by means of a series of connecting-basins containing quicksilver.

To aid the process of amalgamation various processes have been adopted to render desulphurization by roasting more effective, among which may be cited the following : —

Raht, August 21, 1866, forces air through the mass of fused metal, to remove sulphur, arsenic, and antimony. The apparatus may be similar to the "Bessemer."

Ryerson, August 14, 1866. The ores are heated in a muffle in the presence of a current of air ; behind each muffle is a passage in which binoxide of nitrogen is generated, which mixes with the air and sulphurous acid passing from the muffles ; the mixture is driven by fans into receivers in company with a steam-jet. The receivers are charged with ore previously desulphurized in the muffles. The sulphurous acid is converted into sulphuric acid, and combines with the base metals in the receiver ; the sulphates are dissolved out by water, leaving the gold free ; the silver may by the usual method be afterwards precipitated from the solution of mixed sulphates.

Whelpley and Storer, September 11, 1866. In this process the chemical reagents are blown in a finely divided state upon the heated ore by means of a blast of air or steam. The interior of the furnace is stated to have an atmosphere charged with "coal in aërial or air-borne combustion."

Fleury, July 3, 1866, mixes the sulphurets or tailings with coal-dust, and bakes them into a metalliferous coke. This is ground, heated, and treated with steam, after which it is amalgamated.

Brower and Campbell, January 23, 1866. The ores are smelted with a suitable flux, such as carbonate of soda, and the fused mass precipitated into cold water, to disintegrate the mass and expel the sulphur.

Whelpley and Storer, September 11, 1866. The cylindrical vessel is connected with a hopper at one end, an exhaust-pipe at the other end, and has a series of rotary agitating arms attached to a shaft passing through the said cylinder. The hopper has a grating and a feed-brush. Air may be admitted to the cylinder through a grating.

The inventors claim, first, brightening metallic particles in finely pulverized and desulphurized ores, when such brightening is effected on the principle of mutual attrition in a cylinder alternately closed during the brightening process, and opened to set free the charge by means of a valve in the exhaust-pipe, intending to claim for this end the principle of alternately closing and opening the cylinder, so as to do the work in a close cylinder, as well as the combination of the cylinder-valve and exhaust-pipe for the purpose and substantially as described.

A fine grating prevents in the feed-hopper the passage of any but very fine dust into the cylinder.

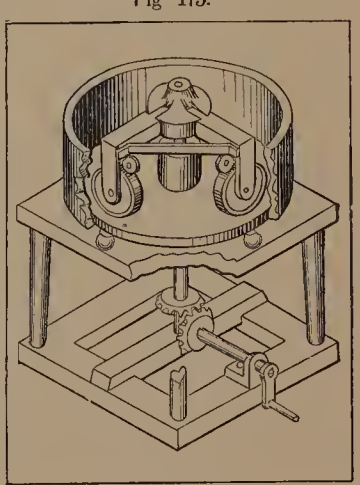
In their patent of June 13, 1865, they separate metals from mixtures of earth and metal by the action of gravity in counteraction to currents of air in an upright pulverizing-mill, the air moving upward to carry off the finer dust of earthy matter, while the metal falls by its superior gravity.

Within the cylindrical case is a revolving shaft provided with blades. The case is provided with a hopper and an air-aperture at the top, and an air-outlet and an outlet for the ore through the conductor at the bottom. The conductor communicates with a box, which is provided with an air-aperture and door. This box communicates with another box by means of a pipe, the latter box being also provided with an air-aperture and a door. A tube leads from this latter box to the center of a spray-wheel which is contained in a box, the bottom of which is covered with water, and the said box is provided with shelves in the upper part.

The same inventors have an apparatus for desulphurizing ores, by roasting, while falling through a chimney above a furnace.

Electric action has been called into play to secure the deposit of gold and silver from the earthy matters with which it is associated, and has also been used to energize the action of the amalgam.

Fig 175.



Corson's Amalgamator.

Corson, May 5, 1868. The ores are contained in an insulated pan or barrel, and subjected to electric action therein. The battery is formed in the pan, and is independent of exterior influences, the anode and cathode being exposed in the slime and amalgam, and connected by a metallic strip.

For other adaptations of Electro-Metallurgy to the collection of the precious metals, see GOLD AND SILVER, ELECTRO-METALLURGIC PROCESSES FOR COLLECTION OF.

In RYERSON'S apparatus, June 4, 1861, the substance containing the gold and silver is introduced into the cylindrical vessel, provided with a hemispherical or dished bottom, in a finely divided state, together with mercury and water. Superheated steam is introduced by the coiled pipe into the bottom of the vessel, escaping into the mass by a series of small holes. The vapor of the mercury is condensed against the bottom of the cover of the vessel, and falls in a finely divided state through the mass.

The extraction of the precious metals by immersing the powdered ore in a lead-bath has been called amalgamation, but the term is incorrect; it forms an alloy, not an amalgam. It will be considered under LEAD PROCESS FOR EXTRACTION OF PRECIOUS METALS.

BURSILL'S English patent of February 12, 1853, describes a mode which partakes of a combination of the mercurial and lead processes, and may be mentioned here.

He treats auriferous and argentiferous ores with an amalgam formed by the union of mercury with a readily fusible alloy of lead and bismuth; or lead, bismuth, and tin. The ore is immersed in the bath of molten metal.

The lead process preceded the mercurial, at least on this continent, having been practised from time immemorial by the Indians of Peru.

HEISTER'S new process for the reduction of arsenical sulphurets and other refractory ores is thus described by the San Francisco Times. "To all outward appearance the machine is very simple, consisting of three barrels, one of cast-iron and two of wood. The iron cylinder is about half filled with sulphurets or pulverized ore, and revolved over a moderate fire for an hour, keeping it below a red heat. The ore, having been thoroughly heated through, is drawn out into a wooden cylinder, and ten per cent of quicksilver added, and the opening then made air-tight, to prevent the fumes of the quicksilver from escaping. After revolving for two hours, the ore and quicksilver are found to be intimately mixed together, and the gold and silver amalgamated. The charge is then drawn off into the third barrel and diluted with water, and after revolving for two hours the quicksilver and amalgam are drawn off. The secret of this process is in this last barrel, used as a settler; for, in every instance, with the most refractory arsenical sulphurets, and with combinations of lead and iron, the quicksilver is found at the bottom, collecting and forming an amalgam containing over ninety per cent of the gold and silver, while the only appreciable loss in quicksilver in a month's working was what was spilt by carelessness outside. The cost of working five tons a day ought not to exceed $30. A five-horse engine would give an excess of power, and by grading the barrels properly two common laborers on a shift could keep the machine going to full capacity."

A process said to yield excellent results was described in the "Alta Californian" of August 30, 1866. See also "American Journal of Mining" (now the "Engineering and Mining Journal"), Vol. II. p. 43 *et seq.*

"The dry rock is crushed, and afterward submitted to the action of balls in a drum to insure full pulverization, it being desirable that the powder should approach as near the fineness of wheat-flour as possible. A charge of this powdered quartz is then placed in an air-tight cylinder, the interior of which is furnished with a worm of pipes to convey superheated steam therein. Added to the charge is a given quantity of quicksilver, which is first heated by the introduction of ordinary steam; the superheated steam is then turned on, and the whole seethed or boiled for an allotted period. On the top of this cylinder a water-bath is placed, and as the mercurial vapors rise they become condensed. Thus the system of thoroughly impregnating the crushed rock with quicksilver is carried out with efficiency. After thus cooking, the cylinder door is opened, and the whole mass discharged upon a novel shaking-table, which is worked by the power of the steam employed in the previous operation. This table is built of copper on a wooden frame, with rollers and riffles of peculiar construction, which, when it is in motion, give the water, amalgam, and dust the same action as the ocean-surf, — an undertow. As the mass descends, the amalgam, from its metallic weight, gradually clears itself from the quartz-dust, and the result is, that it is all collected in the troughs of the riffles, containing every particle of metal, be it precious or base, the quartz holds. The mode of applying super-heated steam to the crushed rock desulphurizes it, freeing the metals, and all that is necessary is to retort the amalgam to obtain the result of the yield."

The "Journal of Mining," August, 1868, mentions the following as a reported success, but without vouching for it: "Zinc added in small quantities to the quicksilver used in amalgamation augments, in a remarkable degree, the retentive power of the latter for gold and silver. It is stated that one ounce of zinc, or less even, should be used to ten pounds of quicksilver. The action in this case is said to be about the same as when sodium amalgam is employed. The beneficial result is thought to lie in the fact that zinc has a tendency to crystallize in a needle or barb-like form; hence, when disseminated in minute particles through the quicksilver, the power of the latter to take up the atoms of gold and silver with which it may be brought in contact becomes very much intensified. This method of increasing the efficiency of the amalgamation process is said to have been in vogue in the Mexican mines."

Many valuable improvements have first been noticed in the current journals of the day, the "Engineering and Mining Journal," "Scientific American," and "American Artisan." Books and their editors cannot keep pace with the march of improvement, which is incessant, and naturally finds its expression in these scientific papers. See also "Mines, Mills, and Furnaces," by R. W. Raymond, United States Commissioner of Mining Statistics: J. B. Ford & Co., New York.

A-mal'gam, E-lec'tri-cal. For covering the cushions of electrical machines.

Zinc, 1 oz.; grain tin, 1 oz.; melt in an iron ladle, and add mercury, 2 oz. Stir with an iron rod, pour into a wooden box chalked on the inside, and agitate till cold; or stir till cold, and then powder.

The powder is spread on the cushion, which is previously smeared with tallow.

A-mal'gam Gild'ing. Grain gold, 1; mercury 8; unite by gentle heat and stirring.

In using, first rub the brass, copper, etc., with a solution of nitrate of mercury, and then spread a film of amalgam. Heat volatilizes the mercury and leaves the gold behind.

A-mal'gam Ma-nip'u-la'tor. A dentist's instrument to facilitate the preparation of amalgam for filling excavations in carious teeth. It has a cup at one end for taking up the desired amount of filings or powder, and a curved spatula at the

other end for combining the mercury with the filings and packing it in the cavity.

A-mal′gam Sil′ver-ing. Silver, 1; mercury, 8; mix with heat, and stir as with gold.

Apply as the gold amalgam, previously using a wash of nitrate.

For silvering the insides of hollow glass vessels, globes, convex mirrors, etc.: —

Lead, tin, and bismuth, each 1 part; melt, mix, and cool to the lowest point at which the alloy will remain fluid; add mercury, 10 oz. Warm the glass, pour in the amalgam, and roll the glass round and round. The amalgam will adhere readily at a certain temperature.

A-mal′gam Var′nish. Melt grain tin, 4; bismuth, 1; add mercury, 1; and stir till cold. Grind fine with white of egg or varnish.

A-man′do-la. A green marble having the appearance of a honey-comb.

Am-a-sette′. A horn instrument for collecting painters' colors on the stone.

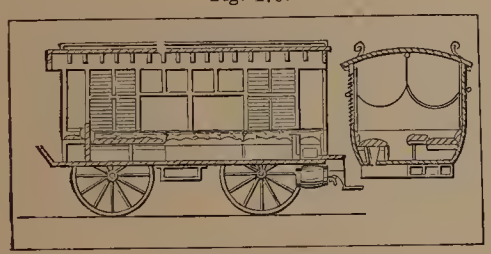
Am′be. A raised stage for a rostrum.

An old chirurgical machine invented by Hippocrates for reducing luxations of the shoulder.

Am′bro-type. A picture taken on a plate of prepared glass, in which the lights are represented in silver, and the shades are produced by a dark background, visible through the unsilvered portion of the glass. — *Webster.* See PHOTOGRAPHY.

Am′bu-lance. Late events in the United States have directed attention to means for the transportation and care of the sick and wounded. Dealing strictly with the mechanical aspects of affairs, it may be stated at once that ambulances are of three kinds, four-wheeled, two-wheeled, and those adapted for pack-saddles.

Fig. 176.



Moses's Ambulance.

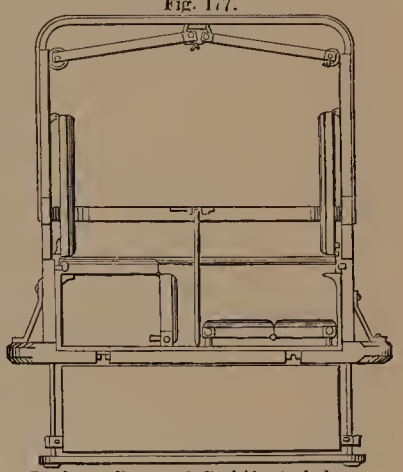
MOSES, September 28, 1858. The sectional folding-seats are arranged along the sides, and may be converted into couches. Hammocks form an upper tier for patients. An adjustable door serves for a table. The surgeon's medicines and implements are carried in cases, which fit in and under the seats, or in drawers under the body of the vehicle. The water-keg is suspended beneath the rear, its faucet defended by the step.

MCKEAN, October 11, 1864. The stretchers are run in longitudinally upon rollers, which rest upon a false bottom suspended by rubber springs from the sides of the carriage. The water-vessel is sufficiently elevated to supply the wounded by a flexible pipe which is under their control. A fan is suspended from the roof. The side-slats are vertical and are controlled by a single rod; their beveled edges enable them to shut closely and present plane exterior and interior surfaces.

ARNOLD, April 5, 1864, suspends his cots upon pivots, which enable them to swing in accordance with the inclination of the ground, so as to avoid the rolling motion of the patient. The pivots themselves rest on springs, which give some resiliency when the carriage receives vertical motion, and thereby lessen the jar.

RUCKER, ALLEN, AND SMITH, November 6, 1866. This is a double or single tier ambulance. Each couch of the lower tier is divided longitudinally and hinged. It may lie flat upon the floor, while the upper tier is occupied by other patients; or it may be bent so as to form a seat and support, while the stretchers of the upper tier are placed on edge against the carriage sides and form backs for the seats. The sides are separately adjustable.

Fig. 177.



Rucker, Allen, and Smith's Ambulance.

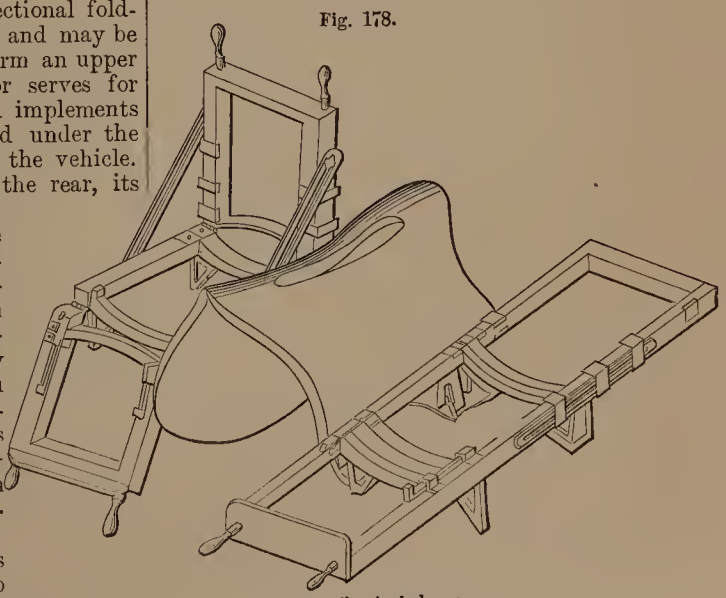
The two-wheeled ambulances are spring carts with provision for recumbent or sitting patients.

HAYWARD, May 16, 1865. The stretchers may be adjusted for recumbent or sitting patients, the legs operating to support them in either capacity when the stretchers rest on the ground. The pack-saddle has wedge-shaped sockets to receive corresponding wedge-shaped blocks on the legs of the stretchers.

SÜS, 1863, WILKINS, 1864, SLATTER, 1865, and others have patented improvements which might be cited would room permit.

This description of service was brought to great efficiency by Baron Larrey, during the wars of Napoleon I. The experience was almost lost in the peace interval, judging by the ambulance arrangements in the Crimea, 1854. At the battle of the Alma, in which 1,986 British and 1,360 French were killed or wounded, the generals of both armies

Fig. 178.



Hayward's Ambulance.

appear to have been taken by surprise. The English were least efficient, the French improvised chairs or panniers slung over the backs of mules, like one of the illustrations preceding. Our own service, 1861–65, was well performed, after things got in running order. Perhaps the Crimean heroes might say the same, with the concluding proviso.

Am'bu-la'tor. Sometimes called a perambulator. An instrument for measuring distances. See ODOMETER. The word "ambulator" is often erroneously applied to a velocipede, and to a traction-engine, whose mode of propulsion is by oscillating bars whose feet come in contact with the ground in somewhat similar manner to the natural action of the legs of animals or of man. The light carriages driven by hands or feet will be considered under the heading VELOCIPEDE. See also TRACTION-ENGINE.

A-mer'i-can Leath'er. An enameled cloth imitating leather.

Am'i-ci's Prism. A glass prism mounted beneath the stage of a microscope to obliquely illuminate an object beneath the stage. The prism has a flat-bottom side and two lenticular sides, combines the refracting and reflecting powers, and throws a converging pencil of rays upon the object. It has three adjustments: one on a horizontal axis to direct the rays upward at the required angle; one for distance from the axis of the microscope, to vary the obliquity; one by rotation on a vertical axis, to determine the direction whence the rays shall proceed.

Am'mo-ni'ac-al En'gine. This motor seems to be yet in an inchoate state, but has received some attention in Europe. The machine described is the invention of M. Froment. The London "Mechanics' Magazine" thus refers to it (it appears to have been at work — or rather in action, for it was not usefully employed — at the Paris Exposition): "Strong liquid ammonia is used in the boiler, and the vapor generated is said to be a mixture of at least eighty parts of ammoniacal gas and twenty parts of steam, so it may be fairly called an ammoniacal engine. The principal recommendations of ammonia, when applied as a motive-power, consist in the small amount of fuel required, and the short time it takes to get up the steam, so to speak. The economy in fuel is very considerable, being about one fourth of that required to generate steam alone. As regards the boiler, it may be of either of the ordinary forms, the only complete novelty being the apparatus for condensing the steam and ammonia. The gas disengaged (about six atmospheres at 110° Centigrade with an ordinary solution of ammonia) does its work in the cylinder and then escapes into the tubes of a condenser, where the steam is condensed and the gas is cooled. The gas then meets with a cold liquid from an injector, which dissolves it, and the solution is carried on into a vessel called the 'dissolver,' from which it is pumped back into the boiler to do its work over again. The liquid for the injector is taken from the boiler, and is cooled before meeting with the ammoniacal gas by passing through a worm surrounded with cold water."

"Ammonia, at the temperature of our atmosphere, is a permanent gas of well-known pungent odor. It is formed by the union of three volumes of hydrogen to one of nitrogen, condensed into two volumes. Its density is 596; air being 1,000. The density of the liquid, compared with water, is 76, or about one quarter lighter than that liquid. Its vapor at 60° Fahr. gives a pressure of 100 pounds to the square inch, while water, to give an equivalent pressure, must be heated to 325° Fahr. The volume of ammoniacal gas under the above-named pressure is 983 times greater than the space occupied by its liquid, while steam, under identical pressure, occupies a space only 303 times greater than water." — *Annals of Chemistry* (French).

"Ammoniacal gas, which is an incidental and abundant product in certain manufactures, especially that of coal-gas, and which makes its appearance in the destructive distillation of all animal substances, is found in commerce chiefly in the form of the aqueous solution. It is the most soluble in water of all known gases, being absorbed, at the temperature of freezing, to the extent of more than a thousand volumes of gas to one of water; and at the temperature of 50° Fahr., of more than eight hundred to one. What is most remarkable in regard to this property is that, at low temperatures, the solution is sensibly instantaneous. This may be strikingly illustrated by transferring a bell-glass filled with the gas to a vessel containing water, and managing the transfer so that the water may not come into contact with the gas until after the mouth of the bell is fully submerged. The water will enter the bell with a violent rush, precisely as into a vacuum, and if the gas be quite free from mixture with any other gas insoluble in water, the bell will inevitably be broken. The presence of a bubble of air may break the force of the shock and save the bell.

"This gas cannot, of course, be collected over water. In the experiment just described, the bell is filled by means of a pneumatic trough containing mercury. It is transferred by passing beneath it a shallow vessel, which takes up not only the bell-glass, but also a sufficient quantity of mercury to keep the gas imprisoned until the arrangements for the experiment are completed.

"The extreme solubility of ammoniacal gas is, therefore, a property of which advantage may be taken for creating a vacuum, exactly as the same object is accomplished by the condensation of steam. As, on the other hand, the pressure which it is capable of exerting at given temperatures is much higher than that which steam affords at the same temperatures; and as, conversely, this gas requires a temperature considerably lower to produce a given pressure than is required by steam, — it seems to possess a combination of properties favorable to the production of an economical motive-power.

"Ammonia, like several other of the gases called permanent, may be liquefied by cold and pressure. At a temperature of 38.5° C., it becomes liquid at the pressure of the atmosphere. At the boiling-point of water it requires more than sixty-one atmospheres of pressure to reduce it to liquefaction. The same effect is produced at the freezing-point of water by a pressure of five atmospheres, at 21° C. (70° Fahr.) by a pressure of nine, and at 38° C. (100° Fahr.) by a pressure of fourteen." — *Barnard.*

LAMM'S Ammonia Engine is driven by the expanding pressure of liquefied ammonia, and is specially adapted for small powers, especially portable engines for street cars, etc. The ammonia is to be liquefied at a central station, at which the reservoirs on the cars receive their supply.

The engine is driven by the force of the gas upon the piston, and the gas is exhausted into a body of water surrounding the gas reservoir. The absorption of the gas by the water is instantaneous, and the water derives an increment therefrom which is imparted, through the walls, to the contents of the reservoir. See "Engineering and Mining Journal," Vol. X. p. 65.

Am-mo'ni-um. The hypothetical metallic base of ammonia. Equivalent, 18; symbol, NH_4. Only

known in its combination with mercury as an amalgam.

The salts of this metal, volatile and otherwise, are used in pharmacy, chemistry, and as stimulants.

Am'mu-ni'tion. In its most comprehensive signification, this includes artillery and small-arm projectiles with their cartridges and the percussion-caps, friction-primers, etc., by means of which they are fired; also war-rockets and hand-grenades. For artillery, when the projectiles, their cartridges, primers, etc., are packed in the same box, it is designated in the United States service as *fixed ammunition;* this is the description furnished for field and rifled siege artillery. For larger calibers, the projectiles and cartridges are put up in separate boxes, round solid shot, however, being generally transported loose.

Up to 12-pounders for smooth-bore ordnance the cartridge is attached to the projectile; above that caliber the shell or case-shot are filled, the fuse inserted, and the sabot attached; in this case, the projectile is said to be *strapped;* shells of 8-inch caliber and upwards are seldom filled previous to issue, this operation being performed as they are required at the place where they are used. Projectiles for rifled artillery are always separate from their cartridges.

Fixed ammunition for field artillery is put up in boxes of uniform size for each caliber, each containing a given number of rounds, viz.: —

Smooth-bore 6-pounder gun . .	14
Smooth-bore 12-pounder gun . .	8
Smooth-bore 12-pounder howitzer .	12
Smooth-bore 24-pounder howitzer .	6
Smooth-bore 32-pounder howitzer .	4
Rifled-bore 3-inch or 10-pounder gun	10

Ammunition for small-arms is known in the United States service as *small-arm cartridges.* In these the bullet and cartridge are invariably put up together in boxes of 1,000, except some descriptions of patented cartridges, which are put up in boxes containing 600 or 1,200, and repeating-cartridges, as Spencer's, in which the box is made to contain a multiple of the number which fills the breech-chamber.

Rules have been laid down for determining the proper supply of ammunition of each description for an army in the field.

That assumed by the British authorities allows 300 small-arm cartridges per man for six months' operations; of which an army of 60,000 men should have 2,680,000 with them, besides those in reserve.

This amount is understood to be in addition to that carried in the cartridge-boxes of the men, 60 rounds each in the case of an infantry soldier.

The wagons for this service are intended to carry 20,000 rounds each, and are drawn by four horses. Several wagons are organized into an equipment under the charge of a detachment of artillery; several such equipments would be attached to an army of 60,000 men, one for each division of infantry and a proper proportion for the cavalry; the remainder being in reserve.

The proportion given in the United States Ordnance Manual is 100 rounds for each man, 40 rounds in the cartridge-box, and the remainder in reserve for infantry.

Ammunition for cannon: 200 rounds for each piece, both of the reserves and active batteries; the ammunition which cannot be carried in the chests of the caissons to be kept with the reserves.

During our late civil war it is believed that, where at all practicable, the amount of readily accessible ammunition, both for artillery and small-arms, was kept largely in excess of the above standard.

A supply-train, under the charge of an ordnance-officer, was attached to each division, from which issues were made as required to the company or regimental officers, upon properly approved requisition.

The wagons of which these trains were composed were generally drawn by six horses or mules, and were capable of carrying from 40,000 to 60,000 rounds of small-arm cartridges, or an equal weight of artillery ammunition.

See WEAPONS; PROJECTILES.

Am'mu-ni'tion-chest. The box in which the fixed ammunition for field cannon is packed. One is carried on the limber of the gun-carriage, and one on the limber and two on the body of each caisson.

The chest is of walnut, and has a hinged lid, which is covered with sheet copper; it is fastened by means of a hasp and turnbuckle, and secured by a padlock.

The interior dimensions are 40 inches long, 18 inches wide, and $14\frac{3}{4}$ inches deep; and it is divided into compartments varying in number from 12 to 50, according to the caliber of the gun, by longitudinal and transverse partitions.

The shot, shell, case, and canister, with their cartridges, are inserted in these compartments, each in a separate part of the chest; and over these is fitted a tray for containing the fuses, friction-primers, and small implements required for the service of the piece.

The chest is fastened in position by means of *stay-pins* and *keys*, and is readily removed or replaced.

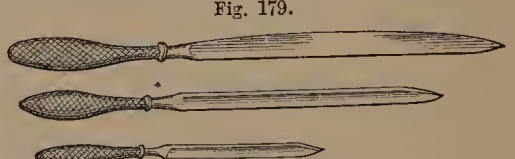
Am'phi-type. The amphitype process in photography is an application of the calotype process, taking its name from the fact of negative and positive pictures being produced by one process. It originated with Sir John Herschel. — *Photographic News.*

Am'pli-tude Com'pass. An azimuth compass whose zeros of graduation are at the east and west points, for the more ready reading of the amplitudes of celestial bodies.

Am-pul'la. Any vessel having a belly, as cucurbits, receivers, etc.

Am'pu-ta'ting-knife. A long, narrow-bladed knife used for making the incisions in amputations. The ancient surgeons endeavored to save a covering of skin for the stump by having it drawn upward previous to making the incision. In 1679, Lowdham,

Fig. 179.



Amputating-Knife.

of Exeter, England, suggested cutting semicircular flaps on one or both sides of a limb, so as to preserve a fleshy cushion to cover the end of the bone. Both these modes are now in use, and are called the "circular" and the "flap" operations. The latter is the more frequently used.

Amputation was not practised by the Greeks; at least, Hippocrates (B. C. 460) does not refer to it and did not practise it. Celsus notices it (A. D. 30). Cautery, pitch, etc. were used to arrest the bleeding. The needle and ligature were introduced about 1550, by the French surgeon Peré.

He was surgeon to Henry II., Francis II., Charles IX., and Henry III. of France, and though a Protestant was concealed in the king's chamber on the night of St. Bartholomew. The king is said to have remarked, "There is only one Paré." A complete set of surgical instruments of bronze was discovered at Pompeii. The tourniquet was invented by Morelli in 1674.

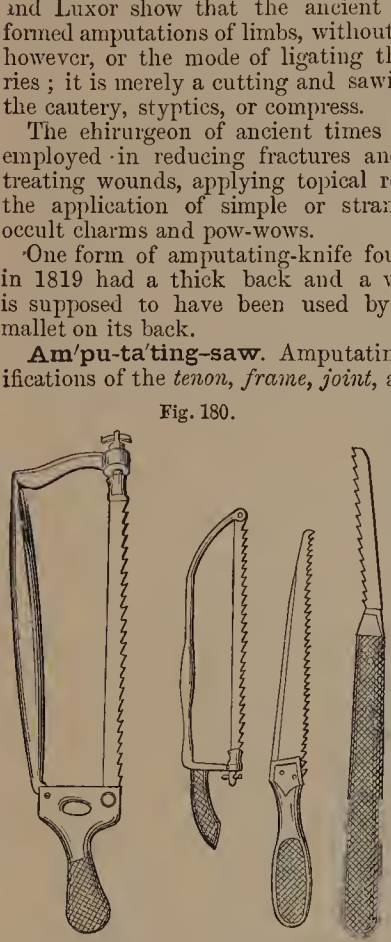
Basso-relievos in the temples of Karnak, Tentyra, and Luxor show that the ancient Egyptians performed amputations of limbs, without the tourniquet, however, or the mode of ligating the severed arteries; it is merely a cutting and sawing, followed by the cautery, styptics, or compress.

The chirurgeon of ancient times was principally employed in reducing fractures and luxations, in treating wounds, applying topical remedies, and in the application of simple or strange drugs with occult charms and pow-wows.

One form of amputating-knife found at Pompeii in 1819 had a thick back and a wavy edge, and is supposed to have been used by the blow of a mallet on its back.

Am'pu-ta'ting-saw. Amputating-saws are modifications of the *tenon, frame, joint,* and *crown saws.*

Fig. 180.



Amputating-Saws.

They are of sizes from 4 to 14 inches in length. Some have edges more or less curved, and the smallest of these dwindle down to a nearly circular plate of steel less than one inch in diameter, serrated round the edge, except where a slender shank terminating in a wooden handle is riveted to the edge of the saw-plate. These are known as Hey's saws, and are used in making exsections, operating on the cranium and metacarpal bones, and in removing carious bones from deep-seated places.

Am'u-sette'. A stocked gun mounted on a swivel, and carrying a ball or charge of buck-shot of from 8 to 32 ounces' weight.

An'a-bas'ses. (*Fabric.*) A coarse blanketing made in France for the African market.

An'a-clas'tic Glass. A sonorous, flat-bellied glass made in Germany, having a thin, flexible, slightly convex bottom, which is capable of flapping back and forth by the expiration or inspiration of the breath when the mouth is applied thereto. As the bottom is drawn in or out it makes a loud crash.

An'a-cos'ta. (*Fabric.*) A woolen diaper made in Holland for the Spanish market.

An æs-thet'ic Ap'pa-ra'tus. Anæsthesia is a term made use of in medicine to denote a deprivation of sensibility to external impressions, affecting a part or the whole of the body. In some nervous diseases a portion of the body may become partially or totally insensible to pain, while the sensibility of another part may become excessively acute, or in a state of hyperæsthesia. The division of a nerve, as is well known, produces an entire deprivation of sensibility in those parts of the body dependent on it.

When the insensibility is confined to the surface of the body it is termed *peripheral;* but when arising from a cause acting on the brain or spinal marrow, from one or the other of which all the nerves emanate, it is called *central.*

Means for inducing temporarily either of these conditions with safety to the patient have been long sought for in surgical practice. The Indian hemp, *Cannabis Indica,* was anciently employed; and it appears that the Chinese employed some preparation of hemp for producing insensibility during surgical operations, more than fifteen hundred years ago. Mandragora was used by the Greeks and Romans for the same purpose, and appears to have continued in use, in combination with opium and other drugs, so late as the thirteenth century, the patient inhaling the vapor from a sponge saturated with these substances. The mandragora, however, at times induced convulsions, and though mention is made of its anæsthetic powers for producing a "trance or a deepe terrible dreame," in operations for the stone, toward the close of the sixteenth century, it, or similar agents, appears to have gradually gone out of use.

It seems a little singular that sulphuric ether should not have been employed for the purpose for some three centuries, unless, as has been suggested, it is the substance spoken of by John Baptista Porta of Naples, who published a book on Natural Magic in 1597; this "quintessence" was extracted from medicines by somniferous "menstrua," and was kept in leaden vessels tightly closed to prevent its escape. The cover being removed, it was applied to the nostrils of the sleeper, who was thereupon thrown into the most profound sleep, etc., etc.

In 1784, Dr. Moore of London tried the expedient of compressing the nerves of a limb preparatory to amputation; but this caused much pain.

Narcotic poisons will induce anæsthetic conditions of the body, in which surgical operations may be performed without apparent pain to the subject. The same is true of alcohol. The peculiar nervous condition induced by what is called animal magnetism has also produced insensibility to pain, during which operations have been performed.

The modern anæsthetic agents are: cold applications, protoxide of nitrogen (laughing-gas), chloroform, ether, amylene, kerosolene.

Sir Humphry Davy suggested the use of protoxide of nitrogen as an anæsthetic agent in surgical operations. It was used by Dr. Wells of Hartford, Conn., in 1844, in dental operations. It has now attained great favor.

Chloroform is a terchloride of formyle (the hypothetical radical of formic acid). Its discovery is claimed by Soubeiran, Guthrie, and Liebig, whose claims have about an even date, 1831. The verdict seems to have settled in favor of the former. Its first use as an anæsthetic was by Dr. Simpson of Edinburgh, 1847.

Hydrate of chloral has recently become quite unpleasantly prominent in the list of anodynes, sedatives, and hypnotics.

Ether was known to the earliest chemists. The discovery of its use as an anæsthetic was made by Dr. Jackson or Dr. Morton of Boston, in 1846. A contest ensued between the parties to prove priority, and was much debated in the scientific journals of the day. In an application to Congress for a remunerative appropriation of $100,000, the rep-

resentatives of Dr. Wells came in with a claim to the first invention. The enterprise failed, but mankind owes a debt of gratitude to each.

Amylene is a colorless liquid obtained by distilling fusel oil with chloride of zinc. It was discovered by M. Balard, of Paris, in 1844. First used by Dr. Snow in 1856.

Kerosolene was derived from the distillation of coal-tar by Merrill of Boston. Its use as an anæsthetic was made known in 1861.

Nitrate of ethyl, of which the chemical formula is $C_4 H_5 O, NO_5$ possesses remarkable anæsthetic properties; it has a very fragrant and agreeable smell, a sweet, but a bitter after taste. Its boiling-point lies at 185° Fahr., and its specific gravity is 1.112 at 62.5° Fahr. It burns with a white flame, is not soluble in water, but easily so in alcohol.

Various forms of apparatus are used in the administration of anæsthetic agents. Some consist of cups which contain the sponge saturated with the liquid and exposed to the current of air as it passes to the lungs. Others pass the air through a body of liquid. The administration of nitrous-oxide requires a different arrangement, and the tube connecting the bladder with the mouth-piece has valves so arranged as to pass the gas to the mouth during inspiration, and allow the expired breath to pass to the atmosphere instead of contaminating and weakening the contents of the bag.

These are more properly considered under INHALERS (which see), as that has become the term by which they are generally known and patented. A class of inventions which preceded the inhalers just described are termed RESPIRATORS (which see), and are not adapted for the introduction of anæsthetic or curative medicaments into the lungs, but are intended as air-heaters or filters, and are used by two classes of persons, — by consumptives to temper the rigor of the air in cold weather, by causing the air to rush rapidly through a succession of narrow passages; and by mechanics, cutlers especially, to arrest particles of steel and grit which permeate the air where the grinding is carried on.

The anæsthetic apparatus which operates by topical application of cold is ordinarily in the form of an ATOMIZER (which see), and consists of a tube whose lower end communicates with a body of liquid, and whose contracted upper end is exposed to a blast at right angles to the axis of the upper tube and across the orifice thereof. This has the effect of raising the liquid, which is dispersed as it reaches the opening, and, assuming the form of fine spray, becomes a great absorber of sensible heat, and consequently lowers the temperature of the air in its vicinity. The air, thus cooled, is projected upon the part where local anæsthesia is required, and by absorbing the heat of the part renders the nervous system of the part incapable of feeling, calloused by cold.

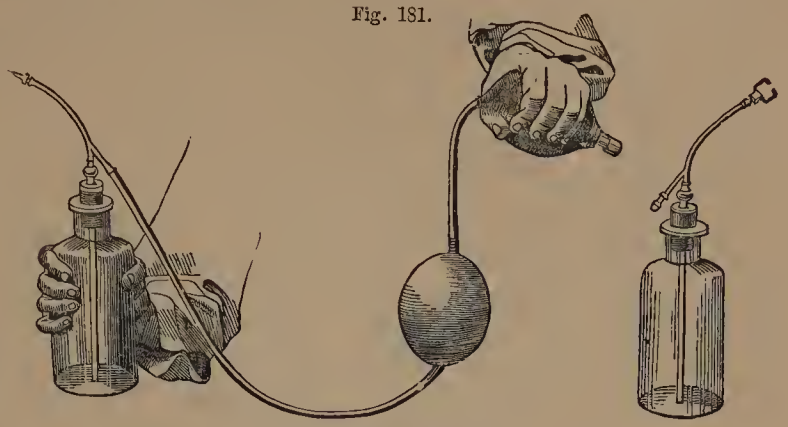
Bags of ice have been laid upon the part affected to produce insensibility by freezing.

For freezing mixtures, see ICE, MANUFACTURE OF.

An'æs-thet'ic Re-frig'er-a'tor. An apparatus for producing local anæsthesia by the application of narcotic spray.

The apparatus consists of a bottle to contain the ether or other fluid to be used; through a perforated cork a double tube is passed, one extremity of the inner part of which goes to the bottom of the bottle; above the cork a tube, connected with the bellows, pierces the outer part of the double tube, and communicates by a small aperture at the inner end of the cork with the interior of the bottle. The inner tube for delivering the ether runs upward to the extremity of the outer tube.

Fig. 181.



White's Anæsthetic Refrigerator.

When the bellows are worked, a *double current of air is produced;* one current descending and pressing upon the ether, forcing it along the inner tube, and the other ascending through the outer tube and playing upon the column of ether as it passes from the inner tube.

Put the ether into the bottle, nearly filling it, then insert the tube with the cork firmly, and fit the nozzle to give the jet desired; the bulb on the extremity of the rubber-tubing, being now grasped in the hand and rapidly used as a hand-bellows, — the other bulb acting as a reservoir, — keeps up a steady pressure upon the ether and produces a continuous jet.

The small wires, called stylets, are used to graduate the spray, which is made finer or heavier by the use of the different sizes.

Remove the nozzle and insert the stylet in the small tube. The hook on one end of the wires is to prevent their slipping into the tube.

Two nozzles accompany the instrument; the straight one for producing a single jet, and the double curved one for operating on both sides of a molar tooth.

An'a-glyph. A chased or embossed ornament.

An'a-glyp'to-graph. An instrument for making a medallion engraving of an object in relief, such as a medal or cameo. A point is passed over the medal at an angle of 45°, and communicates motion to a diamond etching-point. The diamond partakes of the motions of the tracer, following the curves of the object, making the lines relatively open on the sides of the protuberances upon which the light is supposed to strike, and making the lines closer on the sides opposed to the light. See MEDALLIC ENGRAVING.

A'nal-di-la'tor. (*Surgical.*) An instrument for dilating the sphincter muscle for the examination of hemorrhoids or fistula in ano.

An'a-lem'ma. A form of sun-dial now disused.

A'nal-spec'ulum. (*Surgical.*) An instrument for distending the anal opening to expose the inner surface of the rectum, in case of hemorrhoids, fistula in ano, etc. See SPECULUM.

An'a-lyz'er. The upper or eye prism of the polarizing apparatus.

The first of the two columns in the Coffey Still; the second being the rectifier. See STILL.

An'a-plas'tic In'stru-ment. For the operation of forming a nose upon the face. The Tagliacozzian operation. See RHINOPLASTIC PIN.

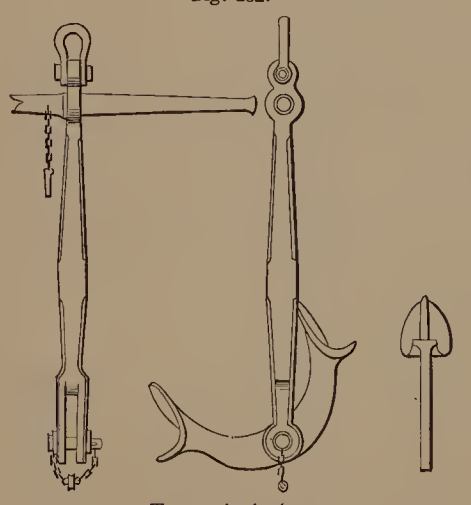
An'a-stat'ic En-grav'ing and Print'ing. Invented by Wood in 1841. An engraving or other printed sheet is moistened with dilute phosphoric acid, and pressed on to a clean surface of zinc, which is etched thereby in the place not protected by the ink. The plate is kept damp by acidulous solution of gum, and in the printing process only takes ink from the rollers at the points where the ink of the original impression first adhered.

Zincography is the term applied to drawing upon zinc for subsequent treatment as above.

An'chor. 1. Anchors were, according to Apollonius Rhodius and Stephen of Byzantium, originally made of stone, or of logs of wood covered with lead. These were succeeded by a bent rod with a single fluke. The invention was ascribed by Pliny to the Tuscans; Strabo ascribes the addition of the second fluke to Anacharsis the Scythian. They were first forged in England, A. D. 578, when Titillus reigned in East Anglia. The general shape of anchors is well known, consisting of two arms terminating in broad expansions termed flukes, and attached to a long shank, to which is fixed a stock of wood or iron at right angles to the arms, to insure the perpendicularity of the flukes when the anchor is on the bottom, in order that they may take firm hold of the ground. Small anchors termed grapnels, and having four or more arms, are used for boats, and at times for small vessels. The mushroom-anchor, so called from its shape, is much employed in the East Indies by the native vessels called grabs. The weight of the largest anchors, for vessels of 1,000 tons or less, is about 1 cwt. for each 20 tons measurement, or .0025 of the tonnage. Various improvements have been proposed upon the ordinary anchor, of which the most prominent are Rodgers's, Trotman's, and its modifications, Isaacs's and Lenox's.

In TROTMAN'S anchor the arms are passed through the shank, which is slotted, and are held by a bolt, thus bringing the upper arm and fluke down on the shank, and allowing the lower one to penetrate deeper when the anchor is on the bottom.

Fig. 182.



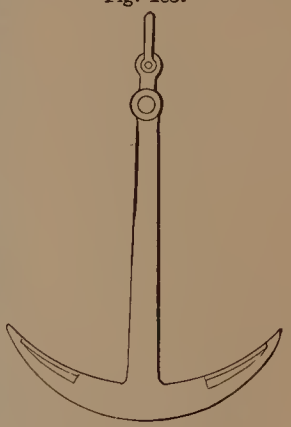
Trotman's Anchor.

This arrangement, aided by the horns on the back of the flukes, also prevents fouling. At a trial made in 1853, under the auspices of the British Board of Admiralty, to determine the comparative general merits of various descriptions of anchors, their comparative merits were decided to be as follows, the Admiralty anchor being taken as unity: —

Trotman	1.28	Honibal (or Porter)	1.09
Rodgers	1.26	Aylen	1.09
Mitcheson	1.20	Admiralty	1.00
Lenox	1.13	Isaacs	.73

Notwithstanding the numerous recent modifications claiming to be improvements, an anchor differing little from the old-fashioned type, excepting that even the very largest sizes have iron stocks, still maintains its place both in the navy and merchant service of the United States.

Fig. 183.

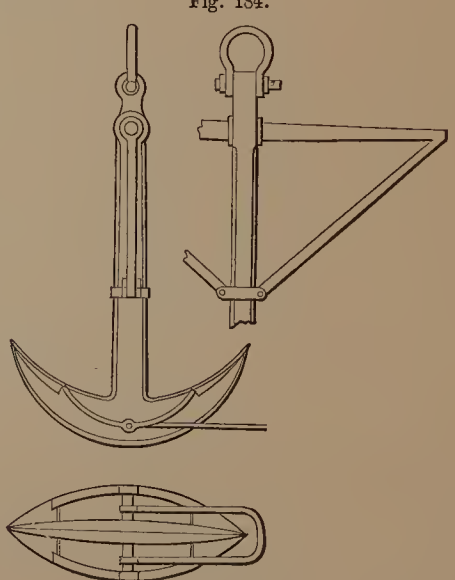


English Admiralty Anchor.

Anchors require to be made of the very best and toughest wrought-iron. They are made by welding together a fagot of bars under a steam or trip hammer, the smaller and more difficult portions being shaped and rounded off, and the whole anchor finished up by hand. This portion of the work, especially in the case of a large anchor, is one of the most arduous labors of the smith's shop; as the workmen are unable to stand the intense heat from the huge mass of red-hot metal and wield the ponderous sledge-hammers employed but for a very short space of time, each strikes his blow and falls back to make room for another, who in turn retires to give place again to his predecessor, and so on until the iron becomes too cool for further hammering. This evidently requires a considerable share of strength, activity, and endurance on the part of the men, who are not only compelled to strike while the iron is hot, but have to put in as many and as heavy strokes as they possibly can in the time.

ISAACS'S anchor has a flat bar of iron from palm to palm, which passes the shank elliptically on each side, and from each end of the stock to the mid-length of the shank are fixed two other bars to prevent fouling.

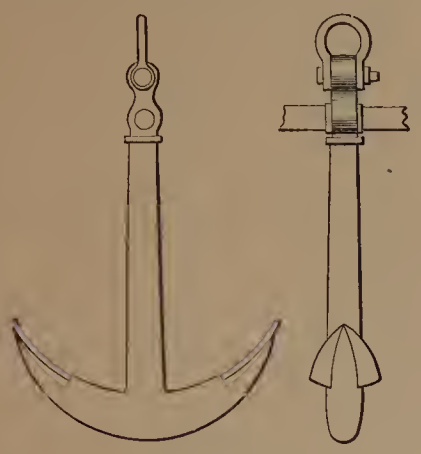
Fig. 184.



Isaacs's Anchor.

PORTER'S anchor, or HONIBAL'S as it is sometimes called from the purchaser of the right, is very similar to Trotman's (which see), the latter being an improvement upon Porter's, with some

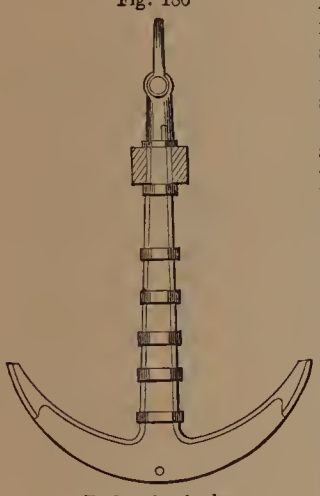
Fig. 185.



Lenox's Anchor.

modifications in the shape of the flukes and their horns. LENOX'S improvement (1832–39) consisted in an improved mode of welding, and in rounding off the sharp edges and lines; also in reducing the size of the palms, the object being to obtain a stronger anchor and prevent injury to the cable.

Fig. 186

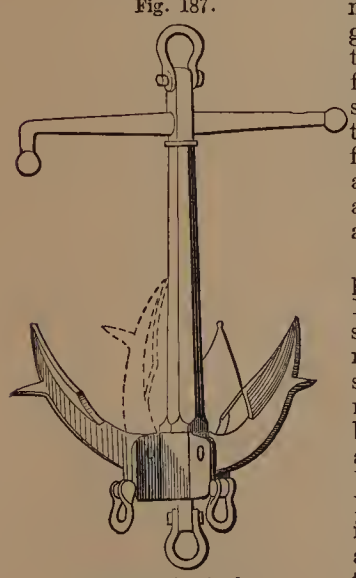


Rodgers's Anchor.

RODGERS'S anchor has a shank with a wooden core, for giving more surface, and consequent strength for a given weight of metal.

WILLIAMS'S anchor, patented March 16, 1858. This anchor has three flukes hinged to a block at the lower end of the shank, and so set that two of them may penetrate the ground at the same time, while the third falls down upon the shank to prevent the cable from being fouled. The flukes are set at 120° apart and hinged in a separate block.

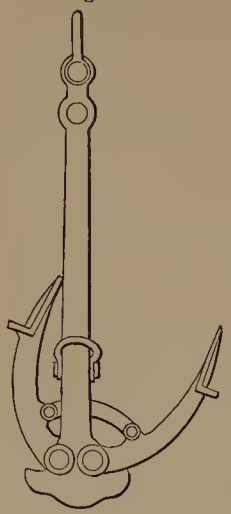
Fig. 187.



Williams's Anchor.

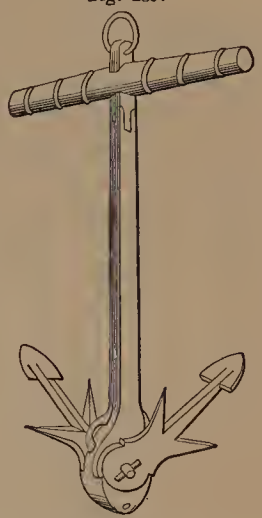
MORGAN'S anchor, patented June 21, 1864. The arms are separately pivoted near the end of the shank, and are connected by a curved bar passing through a hole in the shank. When one fluke has hold of the ground its arm rests against and is supported by the crown-piece, while the other arm falls down upon the shank, obviating the danger of fouling and by means of the curved bar assisting the first arm to bear the strain.

Fig. 188.



Morgan's Anchor.

Fig. 189.

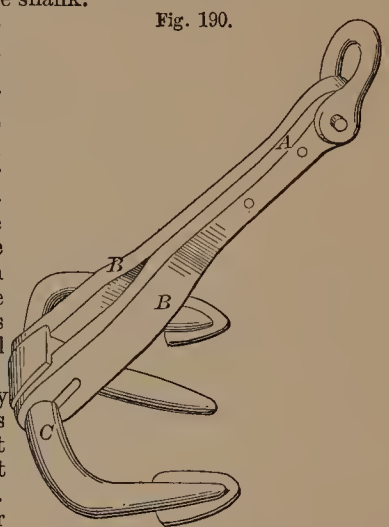


Marshall's Anchor.

MARSHALL'S anchor, patented October 17, 1865. Antedated March 6, 1865.

The arms are straight and turn in an arc of a circle, moving separately on a pivot passing through the crown. Each is provided with barbs or projections to help the fluke to take and retain its hold, and the oscillation is checked by cusps on the thick portion of the crown, so that the arms have a given inclination to the shank.

Fig. 190.



Latham's Anchor.

LATHAM'S anchor, patented August 21, 1866. The shank *A B* is made of two pieces, which separate at their lower ends to allow the passage of the middle fluke. The arm *C* turns in the shank and has three parallel flukes.

The weight by these means is concentrated at the lower part of the anchor. When the anchor is let go, the flukes make about a quarter of a revolution, lying in the position shown in the illustration when they enter the ground. The shoulder on the crown-piece comes against the shank and restrains the oscillation of the arms in either direction, and the anchor stows compactly by bringing the arms parallel with the shank, the middle arm or fluke lying in the space between the two portions of the shank.

STUARD'S anchor. Among the single-armed anchors may be mentioned Stuard's (English), which has a very short shank made in one piece with the arm, the pile being bent, but not welded. The stock is a wrought-iron bar with knobs on the end, which cant the anchor so that its fluke penetrates the ground as it is dragged along. One hole in the

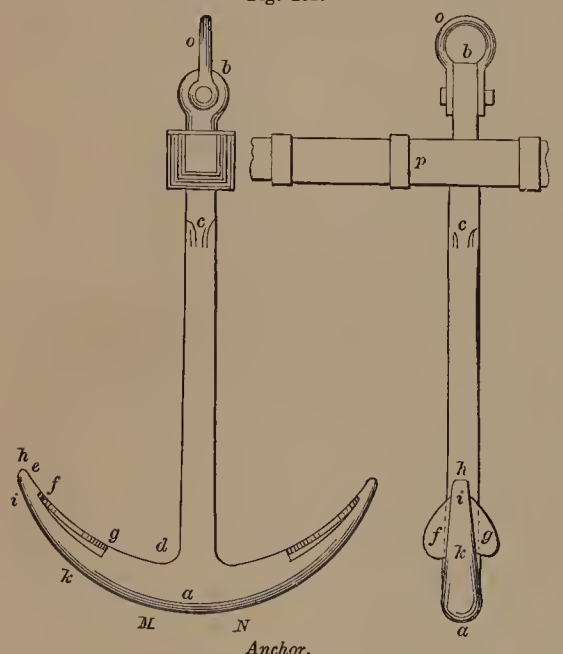
shank is for attachment of the cable, and a shackle at the crown is for the buoy-rope.

The largest anchor in the world, according to Charles Ryland's "Iron Trade Report," was made at H. P. Parke's Works, Tipton, Staffordshire, for the Great Eastern, and weighs eight tons exclusive of the stock. Its dimensions are: Length of shank, twenty feet six inches; of wood-stock, nineteen feet six inches; trend of arms, seven feet four inches. It is somewhat different in form from ordinary anchors, the palms or blades being divided or split so that it may more readily pierce the sea-bottom.

The parts of an anchor are as follows: —

a to *b*, shank; *b* to *c*, square; *d* to *e*, arm; *f* to *g*, palm, fluke, or kevel; *h* to *i*, point, pee, or bill;

Fig. 191.



Anchor.

i to *k*, blade; *M* to *N*, crown; *o*, ring; *p*, stock; *d*, throat or crutch.

For checking and regulating the motion of the cable as it runs towards the *hawse-holes* while the anchor is dropping, and for holding the cable after the anchor has taken hold, four kinds of apparatus are used together or separately, — CONTROLLERS, BITTS, STOPPERS, COMPRESSORS (which see).

To *east* or *drop* anchor is to let go the anchor.

To *ride* at anchor is the condition of the vessel when anchored.

To *swing* at anchor is when the ship obeys the change in the direction of the tide while at anchor.

To *weigh* anchor is to heave it out of the ground.

To *back* an anchor is to strengthen its hold of the ground by means of a second anchor laid down ahead of the other, and fastened to the crown of the latter by a cable.

An anchor is *foul* when the cable is twisted around it or the anchor is entangled with a wreck or another anchor.

The anchor *bites* when the fluke takes hold of the ground.

To *sweep* for an anchor is for the recovery of a lost anchor by sweeping the bottom with the bight of a cable or hawser.

Parting: Breaking cable and leaving the anchor in the ground.

An anchor is *a-cock-bill* when it is suspended perpendicularly from the cathead ready to let go.

It *comes home* when dragged from its hold by the pulling of the cable.

An anchor is *a-stay* when the angle of the cable with the water is about that of a stay. A *long-stay* apeak when coinciding with the *main* stay; *short* stay when with the *fore* stay.

It is *a-peak* when the cable is drawn in so tight as to bring the ship directly over it.

It is *a-weigh*, or *a-trip*, when lifted clear of the ground.

It is *a-wash* when lifted to the surface of the water.

It is *hove up* when lifted to the hawse-hole.

It is *hooked* when cat-fall is fast to the ring.

It is *catted* or *hauled up* when lifted by the ring to the cathead.

It is *fished* when the fluke next to the ship's side is lifted to the fish-davit.

It is *on-board* when the fluke is lifted to its resting-place on the bill-board.

It is *in-board* when on deck.

It is *secured* when all is made fast, the cable and buoy-rope *unbent*, and the anchor *stowed*.

The *weight of Anchor and Kedge* is given exclusive of that of its stock.

Bower and Sheet Anchors should be alike in weight.

Stream Anchors should be ¼ the weight of the best bower.

Kedges are light anchors used in warping.

2. The block, frame, or masonry deeply buried in the earth, to which the cables or wires of suspension-bridges are attached. See ANCHOR, SUSPENSION-CABLE.

An'chor and Col'lar. A form of hinge for a lock-gate. The *anchor* is let into the stone coping; the collar is attached like a clevis to the anchor, and forms a socket for the pintle of the heel-post of the gate.

An'chor-ball. 1. A contrivance of Captain Manby, R. N., for saving life in cases of shipwreck. It is a ball having several hinged prongs fitting in slots, which are intended to catch in the rigging of a stranded vessel.

It is fired from a mortar, and carries a light line by which a stout rope may be carried ashore from the vessel.

The French use a ball for this purpose having a harpoon passing through it, on the rear end of which a line is wound.

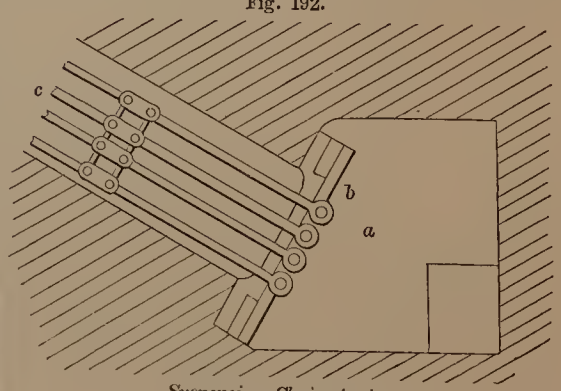
2. A carcass or incendiary ball affixed to a grapnel by which it is intended to adhere to and fire a vessel.

An'chor-bolt. (*Machinery.*) One having an expanded shank to prevent its drawing out.

An'chor-chocks. Blocks on which a *stowed* anchor rests.

An'chor, Sus-pen'sion-ca'ble. The anchors of

Fig. 192.



Suspension-Chain Anchor.

the chains of the Menai Suspension Bridge are cast-iron plates having a bearing against the solid rock. Three oblique circular shafts six feet in diameter and sixty feet in depth were blasted into the solid rock, a considerable space being left between each shaft. At the bottom is a cross-tunnel which runs horizontally and at right angles to the inclined shafts. The iron plates, weighing 2,240 pounds, were fitted into seats in the face of the rock at right angles to the chains which are bolted thereto. *a*, cross-tunnel; *b*, anchor; *c*, suspension-cable.

An'chor-drag. See DRAG-ANCHOR.

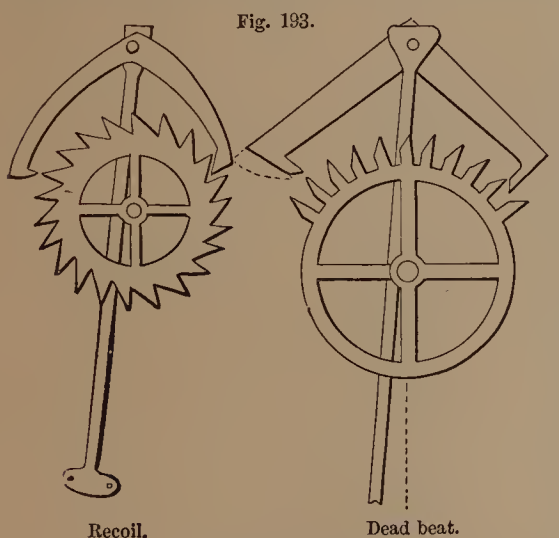
An'chor Es-cape'ment. The anchor escapement superseded the crown-wheel escapement for clocks. It was invented by Clement, a London watchmaker, in 1680. By some it is credited to Dr. Hooke.

The anchor has two arms whose bent ends resemble flukes in some degree, and thus give rise to the name. It is suspended from a horizontal axis, on which it turns freely along with the dependent stem, which terminates at its lower end in a fork or crutch between whose prongs the pendulum-rod passes, so that the motions of the pendulum are communicated to the anchor, and the pressure of the wheel upon the pallets of the anchor is also communicated to the pendulum so as to make up for the small loss by friction incident to its action.

"The great advantage of this escapement over the old crown-wheel is that it allows the escape to take place at a small angle of vibration, thereby preventing the necessity for the maintaining power acting upon the pendulum with so great force as by the old plan; and by the introduction of a heavy ball, leaving that to be done by the uniform power of gravity which before was dependent upon the impulse given by the wheel to the pallets."

Clement, in connection with this escapement, introduced his mode of suspending the pendulum by a thin piece of flexible spring, a mode which has remained in favor ever since.

Fig. 193.



Anchor Escapement.

Figure 193 shows two forms of anchor escapement: one is on the *recoil* principle and the other is the *dead-beat*; the former is so called because each tooth of the wheel makes a back or recoil motion after escaping from the pallet. In the figure one tooth is represented as having just escaped from the anchor, and a tooth on the opposite side of the wheel has dropped on to the pallet. The pendulum continuing its course a little farther to the left, the slope of the pallet will drive the tooth on the right a little way back and produce the recoil.

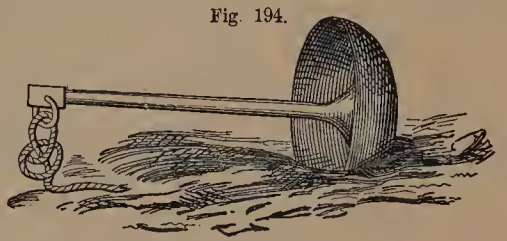
The other figure shows the *dead-beat* escapement, in which the slope of each pallet stops at the points where the teeth fall, the rest of each pallet forming portions of a circle of which the axis is the center. The tooth having passed the pallet, the continued motion of the pendulum merely holds the tooth, but does not give it any backward motion. See DEAD-BEAT ESCAPEMENT; RECOIL ESCAPEMENT.

An'chor-gate. A heavy gate, such as is used in the locks of canals, requires for its upper bearing a collar which is stayed by the adjacent masonry. Barbed metallic projections from the collar are embedded in the masonry, and resist displacement of the gate while enduring strain or swinging on its axis.

An'chor-lin'ing. Sheathing on the ship's planking, under the fore-channels, to keep the bill of the anchor from ripping the ship's side when hauling it up, or *fishing*.

An'chor, Mush'room. The *mushroom anchor* is used for moorings, and is said to be a favorite in the East Indies. Its name indicates its form, having a central shank and a head of a bowl shape, which requires no *stock* on the *shank* to cause it to engage with the ground over which it is dragged.

Fig. 194.



Mushroom Anchor.

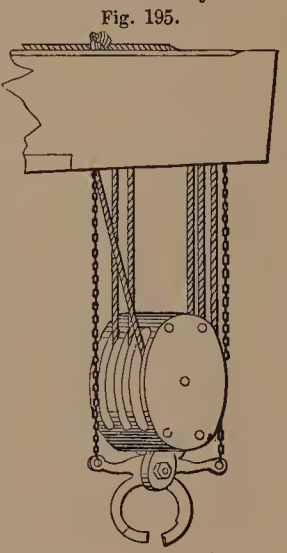
An'chor-ring. The ring of an anchor by which it is bent to the cable. A jew's-harp shackle is now used.

An'chor-stock Plank'ing. (*Ship-building.*) Each plank has one straight edge, the other consisting of two equal slopes.

An'chor-trip'pers. These are devices for "tripping" or casting loose a ship's anchor. In some of them it is suspended by its ring from the cat-block or a tripping-bolt; in others it is fastened at each end by chains which are cast loose simultaneously.

DUNCAN, April 28, 1863. The anchor hangs from a clutch-ring on the cat-block, which is suspended below the cathead. When the fall is cast loose, the block descends, and the clutch is opened by the chains which are attached to the cathead, and to the projecting levers or prongs on the respective halves of the clutch. A single motion, the slackening of the fall, operates the tripper; the clutch is opened when the chains are made taut by the descent of the block.

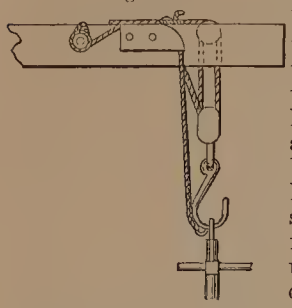
Fig. 195.



Duncan's Anchor-Tripper.

STACEY, December 27, 1864. The anchor is suspended by its ring from

Fig. 196

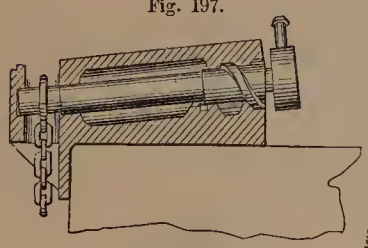


Stacey's Anchor-Tripper.

the hook of the fall-block, which depends from the cat-head. The tripping-rope is attached to an eye on the fall-block hook, and is belayed to a pin on the cat-head. When the fall is cast loose, and as soon as the slack of the tripping-rope is exhausted, the said rope upsets the hook, and casts loose the anchor.

HOLMES, April 28, 1857. A short chain is attached to the ring of the anchor, and the link on its upper end is transfixed by a pin which has its bearings in a block. By turning the handle half a revolution in one direction, the screw upon the shaft will cause the pin to recede, and disengage itself from the link of the chain. The thread works in a spiral groove or nut, by which it receives longitudinal motion when partially rotated.

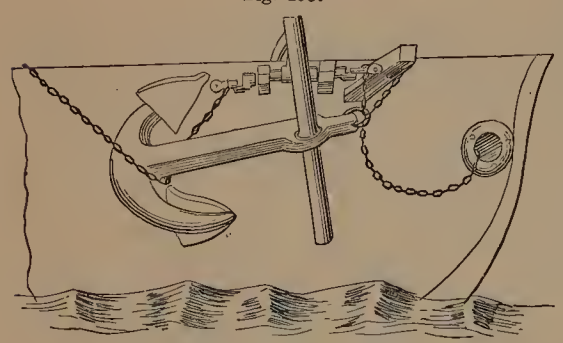
Fig. 197.



Holmes's Anchor-Tripper.

HEITMAN, May 16, 1865. The anchor is suspended by a shank-painter and a ring-stopper. One end of each chain is fast to the vessel, while the ring at its other end rests upon a pivoted latch-

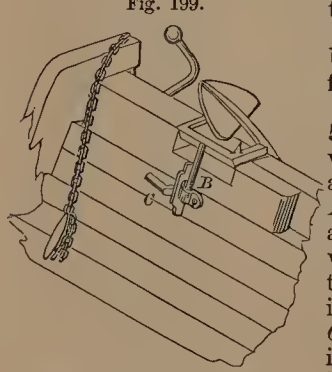
Fig. 198.



Heitman's Anchor-Tripper.

piece. These latch-pieces are supported upon a bar, which is rotated to give simultaneous disengagement to the latches, and cast the anchor loose. The movement of the bar is effected by raising a lever which rests upon the rail.

Fig. 199.



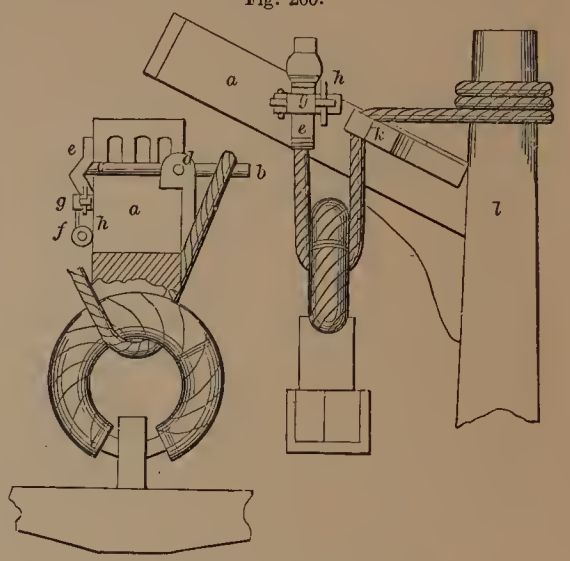
Gibson's Anchor-Tripper.

There are thirteen United States patents for anchor-trippers.

GIBSON, December 5, 1865. In this device the fluke of the anchor rests on a block *A*, which is pivoted in a notch of the gunwale. A bar *B*, attached to said block, is held by a shackle-bar *C*, when the latter is in its upper position. By sliding the shackle in its staple, the bar is released, and the block *A* freed to rotate under the weight of the anchor, which is thereby "tripped."

BURTON'S anchor-tripper (English). The standing end of the cat-head stopper is worked into a

Fig. 200.

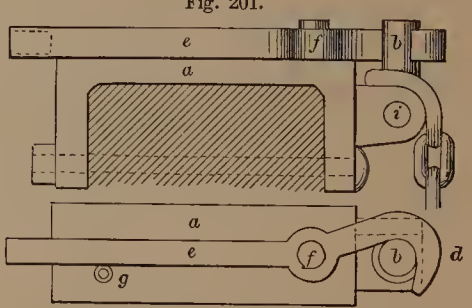


Burton's Anchor-Tripper.

ring placed around the end of the bolt *b e*, which is pivoted at *d*, on the cat-head *a*. The other end *e* of the bolt is oblique, and is held down by the clamp *e*, turning on the pivot *f*, the clasp being secured by a hasp *g*, and pin *h*. The cat-head stopper passes through the ring of the anchor, over the thumb-cleat *k*, and is made fast round the timber-head *l*. When it is required to let go the anchor, a handspike is inserted, so as to bear against the clasp *e*, and hold it closed while the pin *h* is withdrawn, and the hasp *g* is cast off. The handspike being then removed, the oblique end *e* of the bolt throws open the clamp *e*, and the bolt revolving on its pivot *d* allows the standing end of the cat-head stopper to fall off, and the anchor to drop.

SPENCE'S tripper (English) is especially intended for casting off the *shank-painter*, which holds the

Fig. 201.



Spence's Anchor-Tripper.

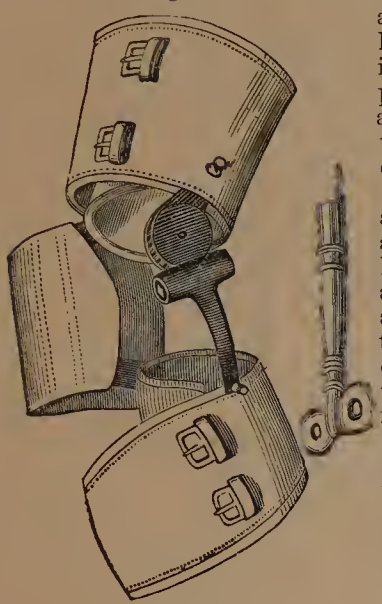
shank and *flukes* to the ship's side, while the *cat-head stopper* holds the *ring* of the *stock*.

a is a carriage bolted to the gunwale; *b* is a bolt which is pivoted at *i* to the carriage, and sustains the chain-end of the *shank-painter*; *e* is a lever pivoted at *f* to the upper side of the carriage *a*, and having a hook *d* at its end which holds the bolt *b* in an upright position. When the *shank-painter* is to be cast off, a pry is taken upon the end of the lever by a handspike till the pin *g* is removed. The

lever *e* is then oscillated till the hook *d* is disengaged from the bolt *b*. The latter is immediately rotated by the weight of the anchor, and the shank-painter is cast loose.

Anch'y-lo'sis Ap'pa-ra'tus. An apparatus for relieving the strain upon the flexed anchylosis articulation by supporting the respective parts of the limb at a distance from the center of leverage.

Fig. 202.



Anchylosis Apparatus.

Fig. 202 shows an apparatus adapted for the knee. The upper and lower bands are secured around the thigh and lower leg respectively, the joint being set immovably at the angle required. The small figure represents the key by which the joint is loosened or locked.

Ancon; Ancone. An elbow or angle. A *quoin.* An ornamental keystone. A *consolc.* The angle of a knee-tumbler.

An'co-ny. (*Metal-working.*) A piece of partially wrought bar-iron, partly finished in the middle, but unwrought at the ends.

An'cove. (*Architecture.*) A console on each side of a door to support a cornice or entablature.

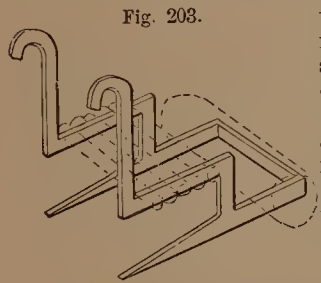
An-cy'lo-mele. A curved probe used by surgeons.

And'i-rons. These are used upon the hearth to support the burning logs and brands. Sometimes called dog-irons, and familiar to all who have been acquainted with the old-fashioned fireplace.

SMYLIE, July 12, 1843. The horses of the andirons are adjustably connected, so as to place them at any convenient distance apart and keep them steady. They are guarded by a safety-bar against the danger of upsetting.

LOGAN, March 27, 1860, has a bottom plate or frame, in combination with two upright angular bars, in such a manner that the same stands firmly in its place and allows a free circulation of the heat.

Fig. 203.



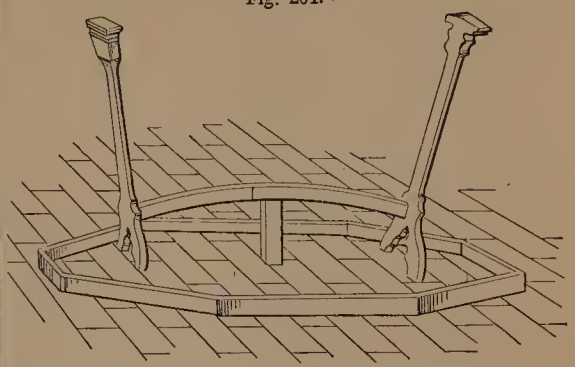
Logan's Andiron.

The name *andiron* is supposed to be derived from the Anglo-Saxon *brand-iron.* Others derive it from *hand-iron.*

For the large kitchen fire, the andirons were very strong and massive, but usually quite plain. In the hall, that ancient seat of hospitality, they were also strong and massive, to support the weight of the huge logs; but the standards were kept bright or ornamented with brass rings, knobs, rosettes, heads and feet of animals, and various grotesque forms. In kitchens, and in the rooms of common houses, the andiron, as its name implies, was of iron; but in the hall the standards were of copper or brass, and sometimes of silver.

Until the seventeenth century wood was the ordinary fuel. It was burned in holes dug in the floor, on hearths in the middle of the floor or against the

Fig. 204.



Andiron.

wall. Chimneys are a comparatively modern invention, and no traces of them are found previous to the twelfth century. See CHIMNEY.

In the baronial halls of England the logs were liberally piled on the hearth in the middle of the hall, being confined within the two standards of the *andiron,* their ends resting on the billet-bar for the purpose of admitting air beneath them, and thus promoting combustion.

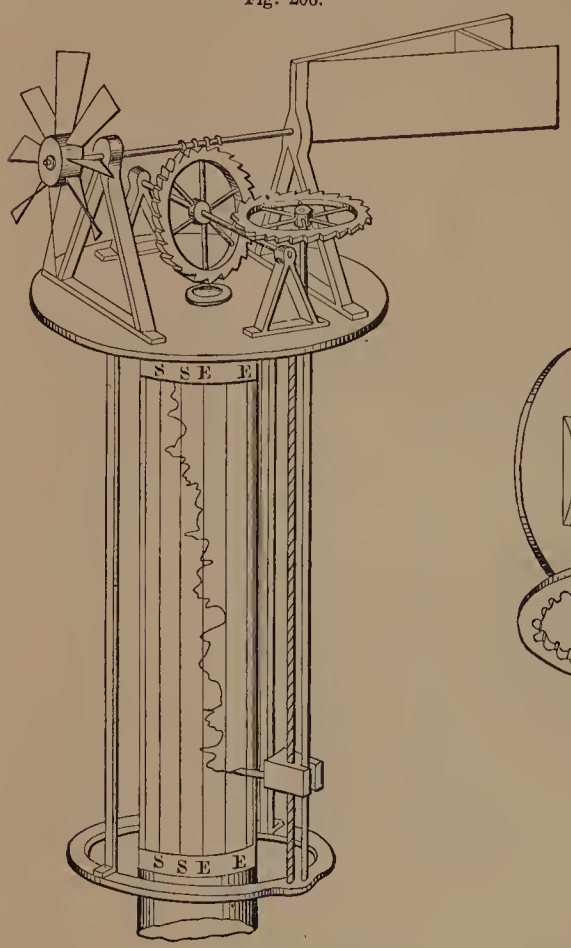
A-nem'o-graph. An instrument for measuring and recording the direction and force of the wind.

An'e-mom'e-ter. An instrument for determining the force of the wind. The most simple form of this instrument is a board or other plane surface of given area, which is presented to the wind and has a spring attached by which the direct force of the wind is measured on a principle precisely similar to that of an ordinary spring-balance. A scale may be attached, which will show the absolute pressure in pounds and fractions to the square foot or inch. The earliest known anemometer was that of Dr. Crombie, 1667, afterwards improved by Wolfius and others. DR. JAMES LIND of Windsor invented, about the year 1775, a very convenient and accurate anemometer which is well suited for private observers or those desiring a portable instrument occupying a small space. It consists of a graduated glass tube having two arms, one of which has the upper part bent perpendicularly; the tube is mounted on a stand, the two arms being in a vertical position, and the bent portion horizontal, so that its mouth can be presented to the wind. Water is poured in until the instrument is filled to the middle or zero of the scale. For use, it is placed so that the mouth shall receive the full force of the wind, which depresses the water in that arm and causes it to rise in the other. As the pressure of the atmosphere at the earth's surface will ordinarily sustain a column of water about 33 feet in height, which is equivalent to about 2,060 pounds to the square foot, if we suppose the wind to blow with a force sufficient to cause a difference of level of one inch in the two branches of the tube, this

Fig. 205.

Lind's Anemometer.

Fig. 206.



Whewell's Anemometer.

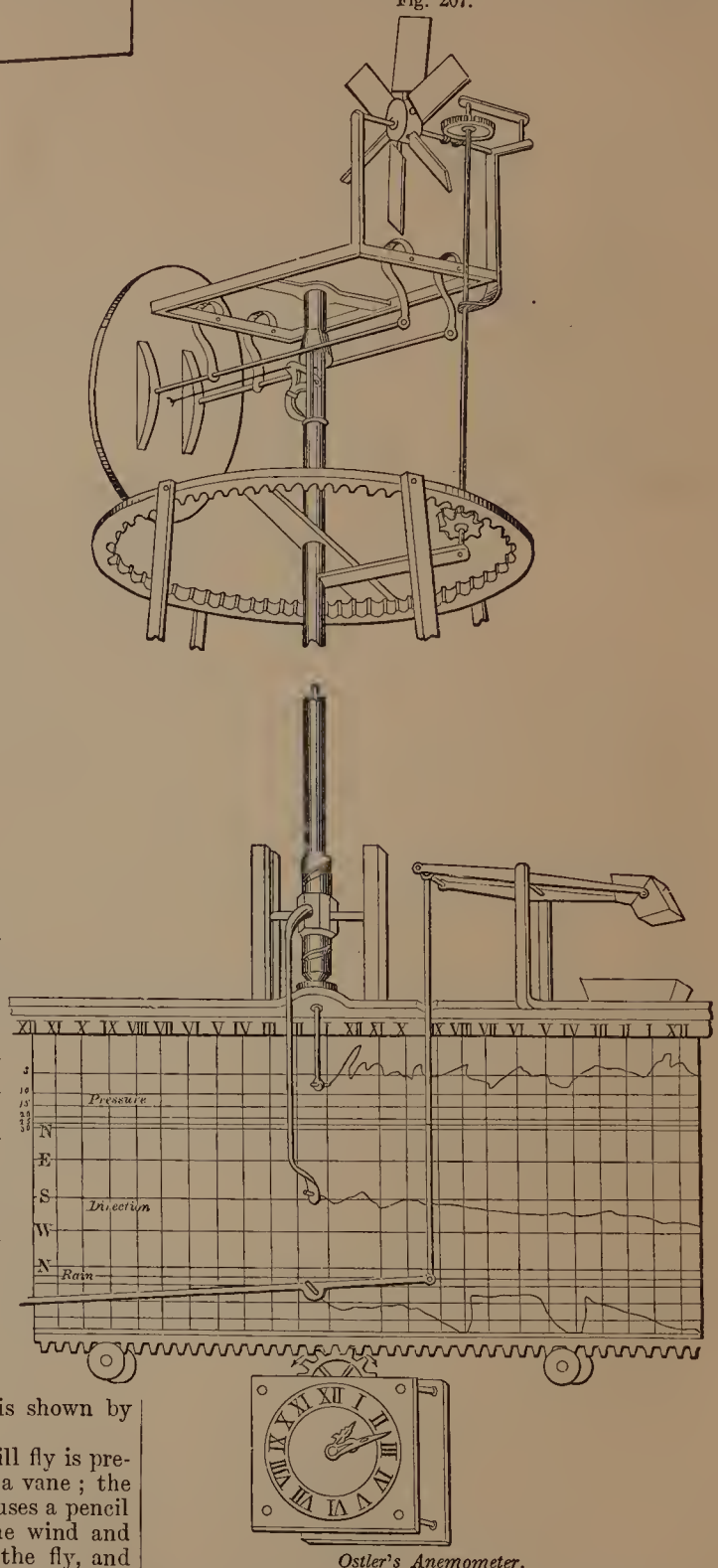
indicates a pressure equivalent to $\frac{1}{12}$ of $\frac{1}{33}$ of the whole weight of the atmosphere, or about $5\frac{2}{10}$ pounds to the square inch. The force being as the square of the velocity, the latter is readily ascertained by calculation, or by inspection from a table engraved on the instrument.

Another form of anemometer is operated by vanes like the sails of a windmill and working on the same principle; their axis has a perpetual screw which turns a vertical cog-wheel on an axis at right angles to the axis of the vanes. To this is attached a bar connected to a counterpoise weight sustained by a cord passing around a cone. The movement of this bar, actuated by the vanes, indicates the comparative force of the wind, which is shown by the dial.

In WHEWELL'S anemometer a windmill fly is presented perpendicularly to the wind by a vane; the fly actuates a train of gearing which causes a pencil to descend, according to the force of the wind and consequent velocity of revolution of the fly, and trace a corresponding line on a fixed cylinder, which is divided by vertical lines representing the points of the compass; as the wind changes, the pencil is moved round on the surface of the cylinder, and caused to register the direction as well as the velocity of the wind, the former by its rotary and the latter by its vertical motion.

Mr. OSTLER'S apparatus, or some modification of it, is probably the most perfect yet devised, especially

Fig. 207.



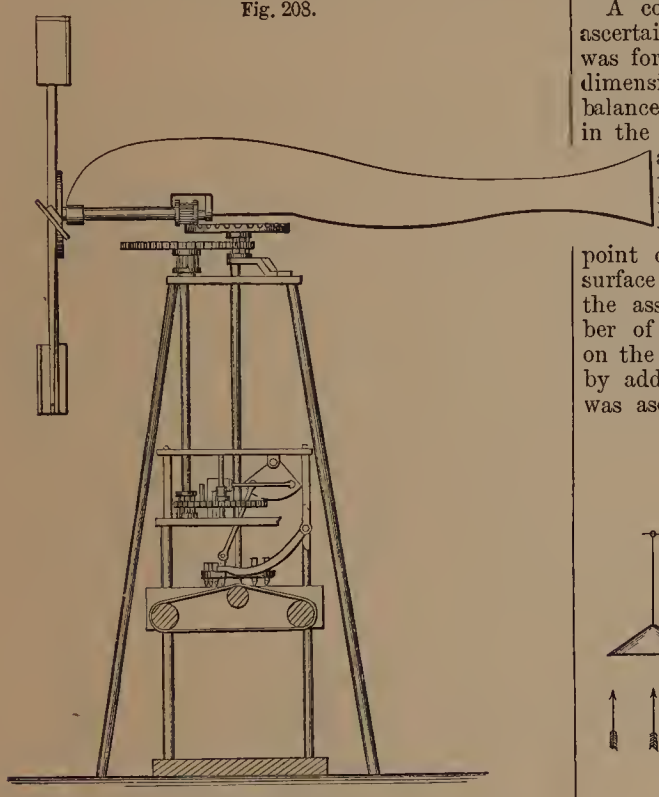
Ostler's Anemometer.

for public institutions, or where it is desired to keep a perfect record of the changes in the force and velocity of the wind. The essential parts are a plate, having its face constantly presented to the wind by a set of vanes at right angles to it; the force of the wind on this plate causes it to move an

arm carrying a pencil, which makes a mark on a sheet of paper especially ruled for the purpose, having separate compartments for registering the force and direction of the wind, and a third to show the amount of rain ; the paper is slowly moved forward by clock-work ; the pencil approaches toward or diverges from the edge of the paper as the force of the wind varies, while a similar pencil, attached to an arm connected by a spiral worm and nut to the guide-vanes above mentioned, registers the direction of the wind in the center compartment. The rain-gage is attached to a bent lever, also carrying a pencil, which is drawn toward the center of the paper as the gage becomes filled with water, thus indicating the amount of rain. When the gage is completely full it tilts, empties itself, and the record commences afresh.

STUNTZ, February 4, 1862. An endless apron moving upon three rollers carries the paper upon

Fig. 208.



Stuntz's Anemometer.

which the record is to be made, a uniform velocity being given to one of the rollers by clock-work. A pencil-holder is attached to the lower part of the vane-shaft, and the proper mark is made on the highest part of the apron above the roller. A pricker, actuated by a spring through mechanism operated by a wind-wheel, makes perforations in the paper, the number occurring in a given length denoting the velocity of the wind during the intervals of time indicated by a scale on the paper.

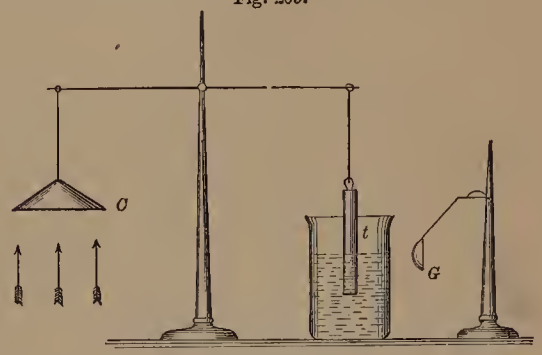
The following table, calculated by Smeaton, shows the force and velocity of the wind : —

Velocity per hour. Miles.	Per second. ft	Pressure per sq. ft. lbs.	
1	1.47	005	Hardly perceptible.
2	2.93	.020	Just perceptible.
3	4.40	.044	
4	5.87	.079	Gentle, pleasant wind.
5	7.33	.123	
10	14.67	.492	Pleasant, brisk breeze.
15	22.00	1.107	
20	29.34	1.968	Very brisk.
25	36.67	3.075	
30	44.01	4.429	High wind.
35	51.34	6.027	
40	58.68	7.873	Very high.
45	66.01	9.963	
50	73.35	12.300	A storm or tempest.
60	88.02	17.715	A great storm.
80	117.36	31.490	A hurricane.
100	146.70	49.200	A hurricane that tears up trees, carries buildings, etc. before it.

About twenty varieties of anemometers are described in works devoted to physics, under the department Meteorology.

A convenient form of anemometer, adapted for ascertaining the force of currents in pipes or flues, was formed by a piece of cardboard *C*, of known dimensions, suspended to one arm of the beam of a balance, and placed at the edge of the mantel-piece in the ascending current. The graduated stem of a broken thermometer *t* was suspended to the other end of the beam, and was placed in a glass vessel containing water ; weights were placed on the card-board till the zero-point of the graduated stem was level with the surface of the water. The degrees were read with the assistance of a magnifier *G*, and the number of degrees moved indicated the force acting on the card. The value of each degree was found by adding weights to the card. In this way it was ascertained that the force of the upward cur-

Fig. 209.



Anemometer.

rent at the mantel-piece was considerable, and that it varied in strength. It was strongest in the center, but extended to both sides of the mantel-piece ; this upward current had a force of from 15 to 4½ grains to the square foot ; the force diminished as the fire got low, but the same action went on even when the fire was extinguished.

The greatest pressure of wind ever registered at Glasgow Observatory was 55 lbs. per foot. Professor Airy, however, states that it may reach 80 lbs. per foot in this country, while Mr. Scott Russell asserts that 40 lbs. per foot is about the maximum force which it is necessary to reckon upon in constructing roofs, etc. This is identical with the maximum registered at Menai Bridge.

A-nem'o-scope. An instrument for showing the course or direction of the wind. A weathercock. It is related that Andronicus Cyrrhestes built an octagonal tower at Athens, having at each side a statue of the god to whom the wind blowing from

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that quarter was dedicated; and in the middle of the tower was a small spire having a copper Triton, which being put in motion by the wind pointed to the deity from whom it proceeded. The custom of placing vanes on the top of church-steeples is at least as old as the middle of the ninth century; and as these vanes were frequently made to resemble a cock, the emblem of clerical vigilance, they received the name of weathercocks. In the ages of ignorance the clergy frequently styled themselves "the cocks of the Almighty."

Varro is said to have been the first who connected the vane by a rod to a dial in the interior of a building.

This instrument is mentioned by Vitruvius, and was introduced in mansions in the time of William III.

On the Hall of Commerce, London, is an anemoscope connected with an index and dial in a room below, like that of Varro above mentioned.

When thus arranged, the shafts connecting the vane and index should be made of cane, bamboo, or other light material.

The anemoscope may be combined with the anemometer, thus indicating both the direction and the force of the wind. See ANEMOMETER.

An'e-roid Ba-rom'e-ter. An instrument for indicating atmospheric pressure, invented by M. Vidi of France. The action of the aneroid depends on the pressure of the atmosphere on a circular metallic box hermetically sealed and having a slightly elastic top, the vacuum serving the purpose of the column of mercury in the ordinary barometer.

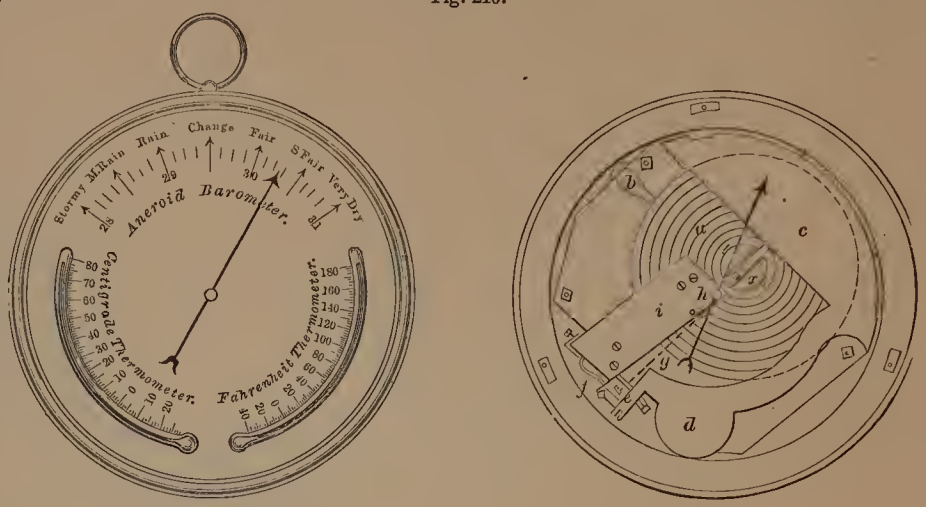
The arrangement is illustrated by the accompanying figures, the first showing the face and the second the interior of the instrument, which is made about $4\frac{3}{4}$ inches in diameter across the face and $1\frac{3}{4}$ inches thick.

The pressure of the atmosphere is shown by the hand pointing to a scale which is graduated with 40 divisions to the inch; one or two thermometers are affixed to the face, but are not essential.

The second figure shows the internal construction, as seen with the face removed, but with the hand still attached. *a* is a flat, circular metallic box, about $2\frac{3}{4}$ inches in diameter and $\frac{1}{4}$ of an inch deep, having its upper and lower surfaces corrugated in concentric circles. This box or chamber, being exhausted of air through the short tube *b*, which is subsequently made air-tight by soldering, constitutes a spring which is affected by every variation of pressure in the external atmosphere, the corrugations increasing its elasticity. At the center of the upper surface of the exhausted chamber is a solid cylindrical projection *x*, about half an inch high, to the top of which the principal lever *c d e* is attached.

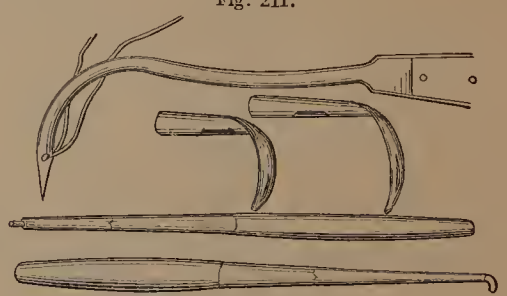
This lever rests partly on a spiral spring at *d*; it is also supported by two vertical pins with perfect freedom of motion. The end *e* of the large or principal lever is attached to a second or small lever *f*, from which a chain *g* extends to *h*, where it works on a drum attached to the arbor or axis of the hand, connected with a hair-spring at *h*, changing the motion from vertical to horizontal, and regulating the hand, the attachments of which are made to the metallic plate *i*. The motion originates in the corrugated metallic box *a*, the surface of which is depressed or elevated as the weight of the atmosphere is increased or diminished, and this motion is communicated through the levers to the axis of the hand at *h*. The spiral spring on which the lever rests at *d* is intended to compensate for the effects of alterations of temperature. The actual movement at the center of the exhausted box from whence the indications emanate is very slight, but by the action of the levers this is multiplied 657 times at the point of the hand, so that the movement of $\frac{1}{220}$th part of an inch carries the hand through three inches on the dial. See also BOURDON BAROMETER.

Fig. 210.



Aneroid.

Fig. 211.



Aneurism Needles.

An'eu-rism Nee'dle. A needle for passing a ligature around a dilated artery.

An'eu-rism Tour'ni-quet. An instrument for bringing a pressure upon a sanguineous tumor resulting from the dilation or rupture of the coats of an artery.

The instrument has two legs and a hinge-joint. The pressure being adjusted as required, the hinge is *set* by the key so as to make it rigid.

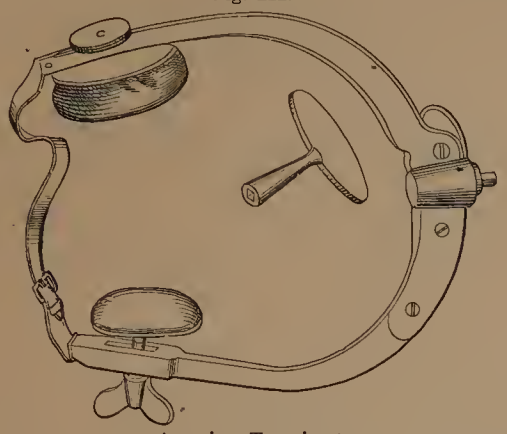
An'gar-i-po'la. (*Fabric.*) A kind of coarse linen made in Spain.

An'ge-lot. A musical instrument of the lute kind.

An'gel-shot. See CHAIN-SHOT.

An'gle. The arris or edge, salient or receding, formed by the junction of two surfaces not in the

Fig. 212.



Aneurism Tourniquet.

same plane. Various are the modes of attaching the two portions; among other devices may be cited: —

Angle-joint.	Feather.	Rebate.
Cramp.	Glue.	Screws.
Dovetail.	Miter.	Tongue and groove.
Dowel.	Nails.	See JOINT.

Pieces at the angles of structures are known as — Angle-brackets, angle-rafters, angle-ribs, angle-bars, angle-staffs, angle-tie, etc.

An'gle-bar. (*Carpentry.*) The upright bar at the meeting of two faces of a polygonal or bow window.

An'gle-bead. A strip having a rounded edge, and placed at the vertical exterior angle formed by plastered surfaces. A beaded-edge angle-staff.

An'gle-brace. A corner-drill. An angle-tie.

An'gle-brack'et. (*Carpentry.*) One beneath the eave at the corner of a building, and projecting at an angle of 45° with the face of each wall.

An'gle-float. A *float* made to fit any internal angle of the walls of a room.

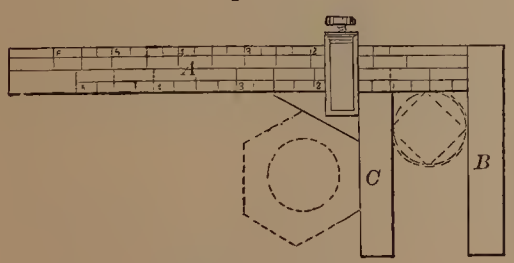
A *float* is a plasterer's trowel.

An'gle-gage. A gage for setting the reflectors on a frame for the exhibition of light under the catoptric system, has two long arms connected by a graduated arc. The arms, having been first placed at the angle which is supplemental to that of the inclination of the axes of the two adjacent mirrors, are made to span the faces of the reflectors, one of which is moved about till its edges are in close contact with the flat surface of one of the arms of the gage.

The instrument has many other applications.

A gage for determining angles of hexagonal nuts. The graduated bar *A* has graduated arms *B* and *C*;

Fig. 213.



Kellogg's Angle-Gage.

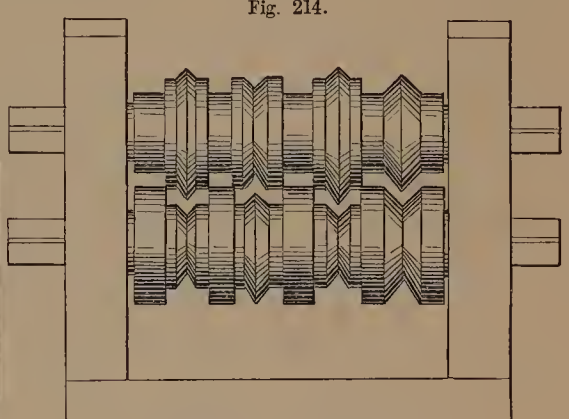
the latter movable, and provided with a block whose edge forms with it an angle of 120° as a gage for hexagonal prisms.

An'gle-i'ron. (*Machinery.*) A bent piece joining the sides of an iron structure. See ANGLE-JOINT.

A description of iron which is used for ship's knees, for uniting the edges of plates which meet at an angle, and for other purposes too numerous to mention. On a larger scale, with more than one bend, it may form a beam, girder, or rail, the difference consisting rather in proportions and purpose than in construction. The fagoting and construction of wrought-iron beams will be considered under BEAM, WROUGHT-IRON. Some devices substantially similar in inventive features will be found under RAILROAD-RAILS, FAGOTING, and ROLLING; the difference between a railroad-rail and a girder is one of shape and proportion of the parts, as will be seen by comparing their cross-sections.

LEWIS, April 26, 1864. The rollers have flat faces, and a central triangular groove, and rib respectively, so that the bar can be introduced between the rollers flat, instead of cornerwise. The effect of this is, that both sides of the angle-iron when finished run parallel to the layers of the original bar, and not crosswise, as is the case with

Fig. 214.

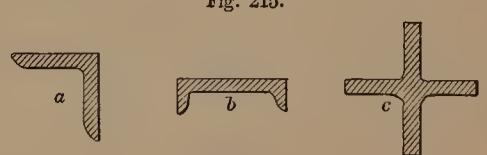


Lewis's Machine for Rolling Angle-Iron.

one side of the angle-iron when rolled in the ordinary manner. The parallelism of the wings with the top of the pile is maintained till the bar is reduced nearly to its proper thickness, when it is finished by passing it through a plain rectangular groove which turns up the wings and finishes them with a grain conformable to that of the original bar.

The ordinary angle-iron is a bar whose section

Fig. 215.

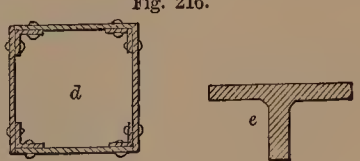


Angle-Irons.

forms two sides of a triangle, but the term now includes other shapes, such as the cruciform, etc.

a is an angle-iron forming two sides of a right-angled triangle; *b* is a flatter form with two flanges, and is called "*channel-iron*"; *c* is cruciform in cross-section. It is called "*cross half-lattice iron.*"

Fig. 216.



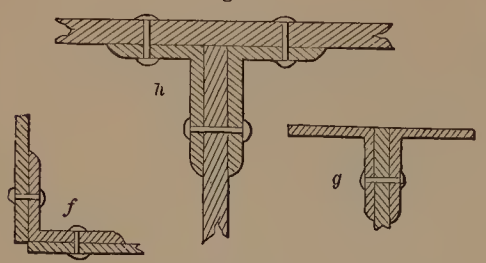
Box-Girder and T-Iron.

d, Fig. 216, shows the application of angle-iron in making a box-girder, or wrought-iron cell; *e* is a form having a *tread* and *web*. It is called T-iron. Other forms are known as Z-iron, I-iron, etc.

Fig. 217 shows the mode of using angle-iron in compound girders, tanks, and other structures.

f shows its application to uniting the angular junction of two plates.

Fig. 217.



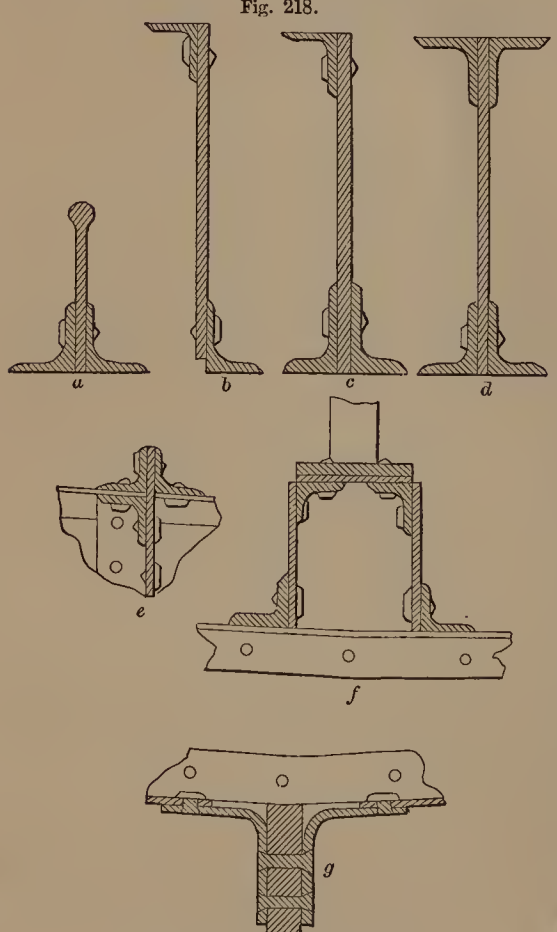
Angle-Irons.

g shows a beam strengthened by angle-plates at each side.

h shows angle-plates uniting a tread-plate and its web.

Angle-bars for shipbuilding are bent and worked into the various forms required in ships, by men called angle-iron smiths; they are then punched with holes, generally about the center of the arm, and by the rivets inserted in these holes the angle-iron is attached to the plates of the ship. The dimensions are usually given in the specification of a vessel in this form, namely, 3 in. × 3 in. × ½ in. This means that each arm of the bar is to be three inches from the angle, and the thickness in the center of arm, or at the rivet-hole, half an inch.

Fig. 218.



Angle-Irons for Shipbuilding.

As angle-iron is generally applied for the ribs of a ship, the arm which is perpendicular to the surface of the plates is that which is in the position to afford the greatest stiffness to the shell. On this account angle-iron has been rolled with arms of unequal lengths, that the greatest strength may be obtained from a given quantity of iron.

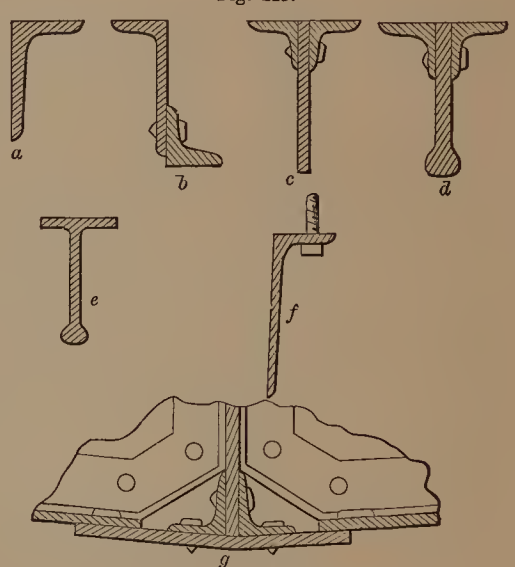
a, *b*, *c*, *d*, are angle-irons and braces for flooring in iron ships.

e shows the connection of outer skin and inner flooring by angle-irons.

f is the arrangement of angle-irons and braces for stiffening ship's bottom longitudinally; answering to the keelson in wooden vessels.

g, keel; showing its connection to the outer skin and beams.

Fig. 219.



Angle-Irons for Shipbuilding.

a, *b*, *c*, *d*, *e*, *f*, are angle-irons and beams employed for flooring in iron ships.

g, outer skin and flooring of an iron steamer without keel; showing the mode of connection of the two, and the longitudinal stiffening-plates and angle-irons of ship's bottom and flooring.

The angle-iron and plates for building iron ships are heated in reverberatory furnaces, of which two are generally placed together, the flues from them leading to one chimney. They are formed of brick and have a brick turned arch, the sides being secured by *binding-plates*, like a *puddling-furnace*.

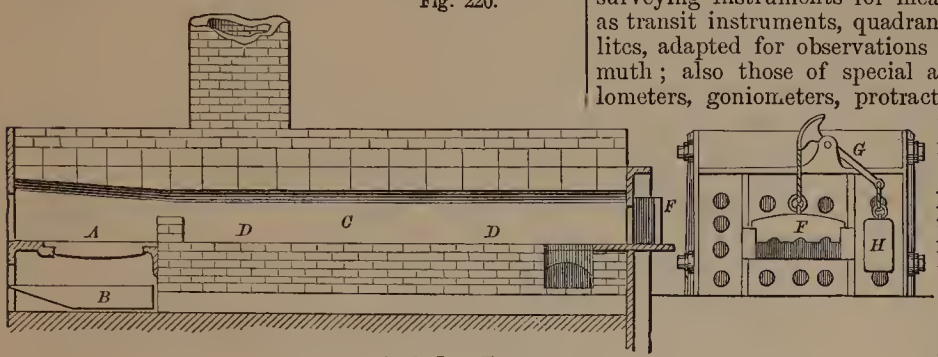
One furnace is made wide, say 4½ × 10 feet, and is suitable for heating plates; the other long and narrow, say 2 feet wide by 25 feet long, and is used for heating the angle-bars which go to make the frame. An iron sill is placed across the doorway on which the *angle-iron* slides in entering or withdrawing.

The furnace *A* has the usual grate-bars, and a pan *B* beneath, filled with water, cools the ashes as they fall and thus preserves the bars from injury.

This furnace is fed with coals, the flame of which passes along the chamber *C*, and over the brick bed *D*, on which the plates or bars are laid. The roof over the whole is a brick arch, about two feet from the bed, acting by reverberation, to concentrate the

heat upon the iron. The flame and hot air then escape down a narrow flue, situated across the mouth of the furnace, and leading by the main flue to the chimney. The end at which the plates or bars are inserted and withdrawn is closed by a door *F*, framed of iron, and enclosing fire-bricks. This, being very heavy, is suspended by a chain, and this chain is attached to a lever *G*, having a balance-weight *H* suspended from it, that the men may have less difficulty in raising and lowering it.

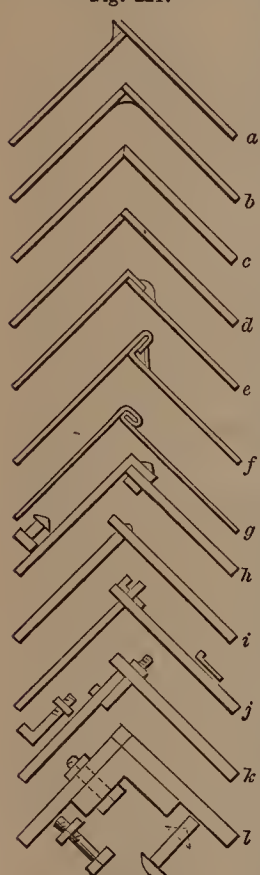
Fig. 220.



Angle-Iron Furnace.

An'gle-joint. Angle-joints differ according to the material, thickness, purpose, and exposure.

Fig. 221.



Angle-joints.

a, *b*, are joints which are entirely dependent upon solder; such are used with tinware and sheet-lead.

c is a *miter-joint*. It is used for thicker metals with hard solders.

d is a *butt-joint;* otherwise similar to *c*.

e is a *lap-joint*; the metal is creased over the *hatchet-stake* or by the *spinning-tool*. It requires solder.

f, one plate is bent rectangularly, and the other is doubly bent so as to recurve back on itself, lapping *around* the edge of the other. It needs solder to keep it from slipping apart.

g has a fold to each plate; these *lock* upon each other and require no solder to perfect their hold, although it may be added to make the joint air and water tight where the closure is not absolutely perfect.

h is a riveted joint, one plate being bent to lap upon the other. This *joint* is called the *folded angle*, and is common in all sizes of work, from domestic utensils to steam-boilers.

i, the edge of one plate is formed into tenons which enter mortises in the other, and are there riveted.

j resembling *i*, except that the tenons are prolonged, so as to be retained in the mortises by *cotters*.

k, one plate makes a butt-joint with the other, and is attached by L-formed rivets or screw-bolts, whose heads are riveted to one plate, while their screw-stems pass through the other plate and are fastened by nuts.

l, the two plates are secured by being bolted or riveted to an angle-iron, which is straight or bent into sweeps according to the shape of the object.

An'gle-me'ter. Any instrument for measuring angles. The term seems to have become more particularly applied to an instrument made use of by geologists for ascertaining the dip of inclined strata.

In the broader sense of a measurer of angles it would include a great number of astronomical and surveying instruments for measuring angles, such as transit instruments, quadrants, sextants, theodolites, adapted for observations in altitude and azimuth; also those of special adaptation, as angulometers, goniometers, protractors, etc., which are treated under their respective heads.

An'gle of Repose'. (*Civil Engineering.*) 1. The utmost inclination at which a carriage will stand at rest upon a road. At the *angle of repose*, the gravity of the load and the friction of the load are equal. See FRICTION.

2. The natural angle at which the soil of a cutting or embankment will stand without slipping. See SLOPE.

An'gle of Sight. (*Ordnance.*) The natural angle of sight is the angle between a line drawn through the axis of the bore, and a line drawn from the rear of the base-ring to the swell of the muzzle or to the top of the sight.

An'gle-plane. A plane whose bit reaches into a re-entering angle.

An'gle-raft'er. (*Carpentry.*) A rafter at the hip of a roof, receiving the heads of the *jack-rafters* or *cripple-studding*.

An'gle-staff. A strip of wood fixed to the vertical angle of a wall flush with the plastering of the two planes. It is designed as a substitute for plastering in a situation so much exposed.

A round staff is known as an *angle-bead*.

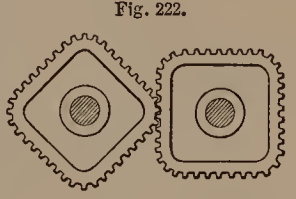
An'gle-tie. (*Carpentry.*) A brace-piece in the interior angle of a wooden frame, securing two side-pieces together and occupying thereto the position of a hypothenuse.

An-go'ra. (*Fabric.*) A light and fashionable cloth made from the wool of the Angora goat.

An'gu-lar File. A locksmith's file for working into the corners of the wards in keys.

An'gu-lar Gear'ing. The wheels are quadrilateral, and the speed of the driven wheel is variable. The driving-wheel, rotating at regular speed, will impart a quicker rate to the other wheel when the angle of the former is in contact with the flat side of the latter, and conversely. Has been used in printing-presses.

Fig. 222.



An'gu-lar In'struments. (*Surveying.*) One in which the horizontal angles are measured by a divided circle and verniers as well as by the needle; as the superior kinds of railroad compasses, the engineer's and surveyor's transits, etc.

An'gu-lar I'ron-band. A ferrule angular in its

cross-section. A square, or other sided collar or binding-hoop.

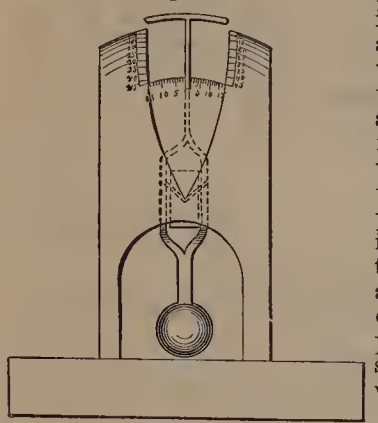
An'gu-lar Thread. A screw-thread whose projection beyond the barrel of the screw is triangular in cross-section. In contradistinction to a *square* thread.

An-gu-lom'e-ter. This instrument is defined by Francis as one for measuring exterior angles. The terms angle-meter and goniometer might be held to mean the same thing judging by their derivation, but the former is applied to instruments used by geologists for measuring the dip of strata, and the latter for measuring the angles of crystals.

A try-square may be termed an angulometer, "a bent measure."

THAYER, August 26, 1862. This invention consists in so constructing and hanging a pendulum, and connecting it with a portion of the surface of a sphere, that it will indicate at once whether any plane to which it is applied is level; and if not so, will show the degrees of the angle, whether of elevation or depression, which such plane makes with the horizon.

Fig. 223.



Thayer's Plane Angulometer.

The pendulum moves upon three or more bearings in the same plane, and carries upon its top a graduated arc, acting in combination with the spherical surface and the opening therein.

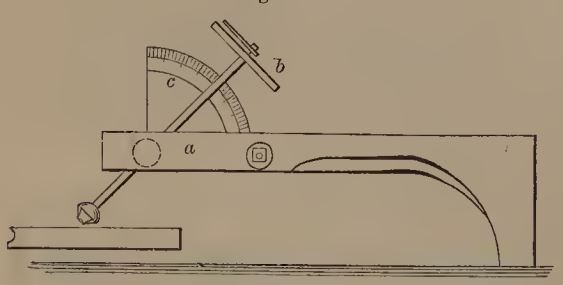
Fig. 224.

Hall's Angulometer.

HALL'S angulometer has two hinged legs, and a graduated arc which indicates the dihedral angle.

An instrument called a *cadrans*, for measuring the angle for the facets of gems in cutting and polishing.

Fig. 225.



Genevese Angulometer.

The gem is cemented on the end of a rod which is clamped between the jaws *a*, which are closed like a vise by means of a set-screw passing through them. Each of the jaws has on the inside a hemispherical cavity into which is fitted a brass ball. A tube passes through the ball, and carries at its upper end a small graduated disk. The cement-stick, carrying the stone to be cut, fits within the tube sufficiently tight to hold it while a facet is being cut, and the upper end of the stick has a pointer by which the divisions on the disk are read off.

Fig. 226

Noose Clutch.

The vertical angle of the tube is determined by the quadrant *c*, fixed on one side of the jaws *a*, and the tube is retained at any angle by closing the jaws upon the ball. The divisions of the quadrant admit of any degree of vertical inclination upon the *skive*, or of vertical position when grinding the *table* or *collet*.

The facets around the stone will be determined by twisting the cement-stick in the tube, until the index marks the required division on the disk *b*.

An'i-mal Black. Carbonaceous matter obtained by the calcination of bones in close vessels. Used in filtering, deodorizing, defecating, discoloring syrups, liquors, solutions.

An'i-mal Char'coal. Calcined bones prepared for sugar-refining. See BONE-BLACK FURNACE.

An'i-mal Clutch. A gripping device for catching animals by the leg. It is especially used for slinging animals during the operations of slaughtering.

In the noose form, Fig. 226, the chain is attached to one end of the plate, and the key on the end of the chain engages in the slot to form a bight for looping around the leg of the animal.

In another form, Fig. 227, the gambrel of the animal is clutched by the gripping-jaws which are attached by chains to the frame, whose roller travels on a way-rod to transport the hog from the "sticker" to the scalding-tub, or from the latter to the "gutter."

Fig. 227.

Hog-Hoister.

An'i-mal'cule Cage. A cell in which living microscopic objects are kept and exposed to view.

An'i-mal-iz'ing Fi'ber. The process of conferring upon vegetable fiber the physical characteristics of animal fiber. Cotton, under the microscope, is a ribbon-shaped tube, and when treated with a cold, strong solution of caustic soda, shrinks and assumes the form of a simple cylinder. It becomes stronger, smaller, and has an increased capacity for receiving coloring matter.

An'i-mal Poke. A yoke placed upon an animal to keep it from pushing down or jumping fences. See POKE.

An'i-mal Pow'er. The expression of the numerical values of the results of the labor of men and animals, particularly horses, is a subject which on account of its eminently practical bearing has attracted considerable attention among scientific as well as practical men.

A work entitled "De Motu Anamalium" was published as far back as 1680 by Borelli, but Coulomb, who devoted a great deal of attention to the matter, has furnished more information of practical value than any other writer.

The unit of value employed by Coulomb was 1 kilogramme (2.2047 pounds) transported a distance of one kilometre (6.214 miles) the total force exerted being estimated by the number of kilogrammes of the burden multiplied by the number of kilometres it is transported during a working day of eight hours; these measures are of course readily reducible to any other denominations, as pounds and miles.

Coulomb ascertained that on an average a man

could travel unloaded 31 miles per day; and supposing his weight to be 160 lbs., the expression for the effect exerted by him would in this case be $160 \times 31 = 4,960$ pounds carried one mile per day. He found also, by the average of the work performed by the porters of Paris, that a man could carry a burden equal to 128 lbs. 9.72 miles per day. Assuming the weight of the man to be 160 lbs., the total effect produced would be equivalent to $160 + 128 \times 9.72 = 2,799$; but the transportation of his own weight formed no part of the useful effect, which is consequently expressed by $128 \times 9.72 = 1,244$.

The useful effect is found to be at a maximum when a man is loaded with 121 pounds; under this burden he can walk $10\frac{1}{3}$ miles per day, giving an effect of $121 \times 10\frac{1}{3} = 1,250$.

A porter going short distances with a burden and returning unloaded, as usually occurs, carries 135 lbs. 7 miles per day. A man can wheel 150 lbs. in a wheelbarrow 10 miles in the same time.

The maximum effect of a strong man exerted for $2\frac{1}{2}$ minutes is estimated at 18,000 pounds raised one foot in a minute; and the force of a man of ordinary strength exerted in lifting is equivalent to 30 lbs. raised $2\frac{1}{2}$ feet per second for ten hours, or 4,500 lbs. raised 1 foot per minute; the estimated power of a horse being equivalent to 33,000 pounds raised one foot in the same time, according to Boulton and Watt's experiments.

The following statement by Hachette shows the force exerted by the strength of men applied in various ways, expressed in terms equivalent to the number of pounds carried by a man one mile during a day of eight hours.

Drawing a light four-wheeled wagon over moderately uneven ground . .	857 lbs.
Pulling horizontally at a rope attached to a weight and passing through a pulley	378 "
Rowing in a boat	374 "
Pushing horizontally, as at a capstan .	368 "
Turning a winch and axle . . .	159 "

The above estimates are based on the average strength of men generally, and in many instances, especially in carrying weights, are largely exceeded; thus it is said that a London porter will carry 200 lbs. on his shoulders at the rate of three miles an hour, but such efforts cannot be sustained for any great length of time. The porters of Constantinople are said, by a judicious distribution of their burdens, to carry much greater weights than this for considerable distances.

The useful effect of a horse walking in a circle, as in turning a mill, is estimated at	800 lbs.
A horse carrying a load of 200 lbs. 25 miles per day	5,000 "
An African dromedary carrying his rider (160 lbs.) can travel for 9 or 10 hours at the rate of between 7 and 8 miles per hour; say $160 \times 9\frac{1}{2} \times 7\frac{1}{2} =$	11,400 "
An Asiatic camel can carry a load of from 500 to 800 lbs. at the rate of $2\frac{1}{2}$ hours; this for a day of 8 hours would give (assuming the load to be 600 lbs.) $600 \times 8 \times 2\frac{1}{2}$ or . .	12,000 "

A draft-horse can draw 1,600 lbs. 23 miles per day, the weight of the carriage being included.

In hauling for short distances and returning unloaded, a horse will draw on a good road 2,000 lbs. or more, exclusive of the weight of the cart.

In drawing a load the greatest effect is found to be produced when the traces are perpendicular to the collar; as the position of the horse changes in heavy pulling, the traces become more nearly parallel to the road. With very heavy drafts, loading the back of a horse is found rather advantageous than otherwise, by not compelling him to incline forward so much and enabling him to use his muscles in a more advantageous position. The circle in which a horse moves in turning a mill should not be less than 25 or 30 feet; 40 feet is better.

According to Tredgold, a horse can draw, as indicated by the dynamometer, 125 pounds at the rate of $2\frac{1}{2}$ miles per hour, which for one day will give $125 \times 2\frac{1}{2} \times 8 = 2,500$. By the experiments of Boulton and Watt they determined that a good horse can draw 125 pounds at the rate of 3 miles per hour, $125 \times 3 \times 8 = 3,000$ pounds one mile in a day. Multiply this amount by the number of feet in a mile, and divide the product by the number of minutes in 8 hours; the result is 33,000, which stands for the number of pounds raised one foot per minute, and this is now the admitted measure of a horse power.

An'i-mals. In the nomenclature of the mechanic arts, the names of animals have not been entirely overlooked e. g.: —

Ass.	Cricket.	Hound.	Rat.
Bear.	Crow.	Jack.	Seal.
Bee.	Dog.	Jenny.	Serpent.
Beetle.	Dolphin.	Kite.	Skate.
Buck.	Drill.	Leech.	Slug.
Buffalo.	Fish.	Lizard.	Snail.
Bull-dog.	Fly.	Mole.	Sole.
Butterfly.	Fox.	Monkey.	Starling.
Camel.	Frog.	Mouse.	Swift.
Cat.	Goose.	Mule.	Throstle.
Cock.	Hawk.	Pig.	Turtle.
Cow.	Hedgehog.	Pike.	Urchin.
Crab.	Hog.	Ram.	Worm.
Crane.	Horse.		

Each of these useful animals is described in its alphabetical place.

An'i-mal Trap. A device for catching animals. There are numerous varieties; some to set in the path of the animals, others are pulled off by a person on watch; the more common forms are those in which the animal is the cause of his own capture by meddling with the bait, or by crawling into his prison in search of food.

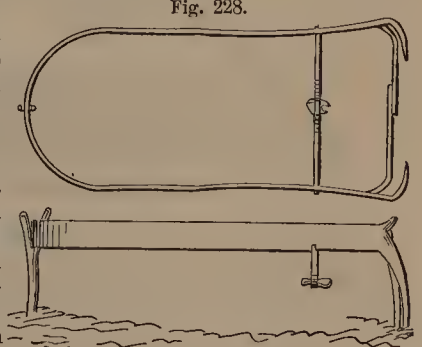
A few instances of different arrangements will be given.

1. The *guillotine-trap* has a descending knife or row of spikes which descends vertically upon the animal which is tampering with the bait.

2. The *rotating-claw* is actuated by a spring on the axis, and is released by nibbling at the bait. It strikes the animal, and throws him to a distance, resetting itself.

3. The *dead-fall* is a weight or spring bar, released by the animal, either by stepping on a platform or touching the bait.

Fig. 228.



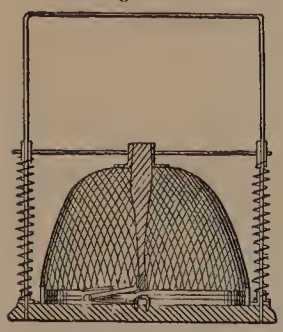
Spring Jaw-Trap.

4. The *gripping-jaw-trap* is shown in the familiar form wherein the jaws are actuated by a spring released by the depression of a small platform between them.

Another form of jaw-trap is

seen in Fig. 228, in which the spring and jaws are made of one strip of steel, and the brace, which keeps them apart, has the bait attached ; a trigger releases the jaws, which grasp the animal that is pulling upon the bait.

Fig. 229.



Falling-Cage Trap.

The illustration shows the mode of setting the trap. The forward part stands on two legs, and the bow at the rear is supported on a little crotch.

5. The *falling-cage*. This may be a wire basket, as in Fig. 229. The bell-shaped cage is suspended vertically above the platform ; it rests upon a toggle-jointed bar, and is released by the baited trigger, which allows the toggle to double up.

Another form of dropper is shown in Fig. 230. A disk with a circular series of vertical wires.

Fig. 230.

Dropping-Cage Trap.

The arm which rises vertically from the falling disk has at top a staple which rests on the top of a vibratable lever, to which the bait is tied.

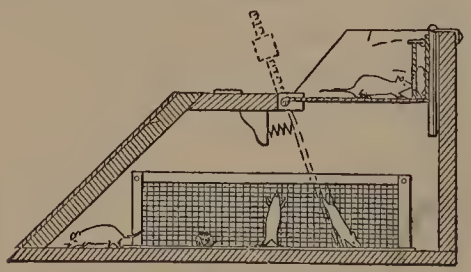
The fall of the disk imprisons or impales the animal.

6. The *gravitating-platform* has many forms. Fig. 231 may be taken as an illustration.

Pressure on the swinging bait-box releases the platform, which swings and precipitates the animal into the cage beneath. The adjustable weight returns the platform to place, when it becomes reset.

The essential features of these traps are a falling platform, a resetting device, and a receiver beneath. The resetting is sometimes done by a spring, sometimes by a weight, in some cases by the animal in passing to an interior chamber.

Fig. 231.

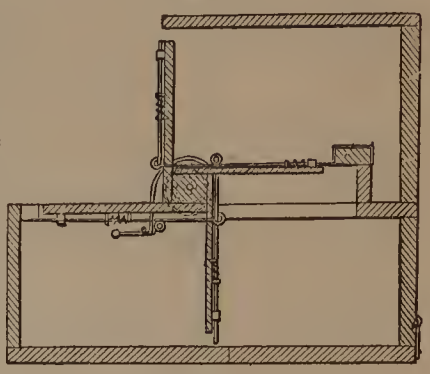


Falling-Platform Trap.

7. The *rotating-platform*, Fig. 232, has a number of platforms brought successively into use.

A series of wings is attached to a rotary-shaft that is actuated by a weighted cord, so that they consecutively assume a horizontal position, forming a platform upon which the rat stands while nibbling at the bait, and from which he is thrown down into the trap.

Fig. 232.

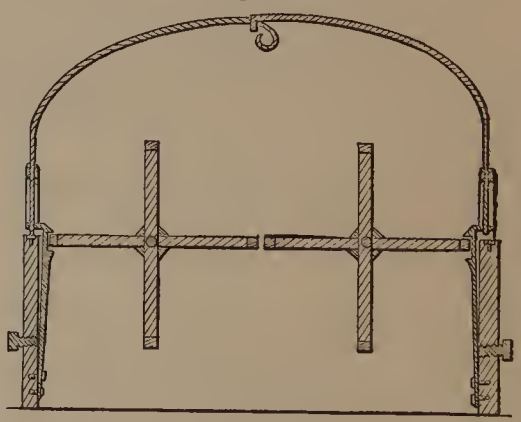


Rotary-Platform Trap.

In another form, the wheel is rotated by a coiled spring, the radial wings being in turn detained by their latches, which catch upon a detent-lug on the case. The motion of the oscillating platform disengages the latch, the wing descends, and the next becomes ready for duty.

Fig. 233 has a duplication of the rotary feature. The invention consists of two radial rotating-platforms, each held in position by separate triggers, but the wires controlling them come together at the bait-hook, which forms one of them.

Fig. 233.

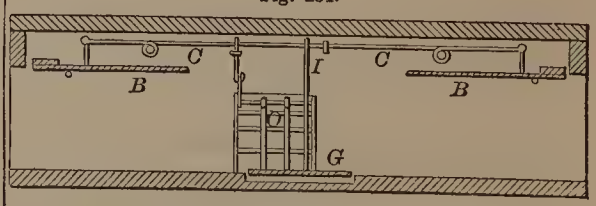


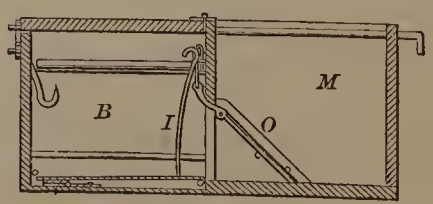
Gatchell's Trap.

Each wire is connected with a rock-shaft, and the triggers or detents are withdrawn by the pulling of the bait by the animal, whose resting-place is at the center, upon two wings. Upon the animal falling into a receptacle below, the trap is reset.

8. The *falling-door*. Several forms of traps which come under this class are familiar to the public, some with one door, and some with two.

Fig. 234.



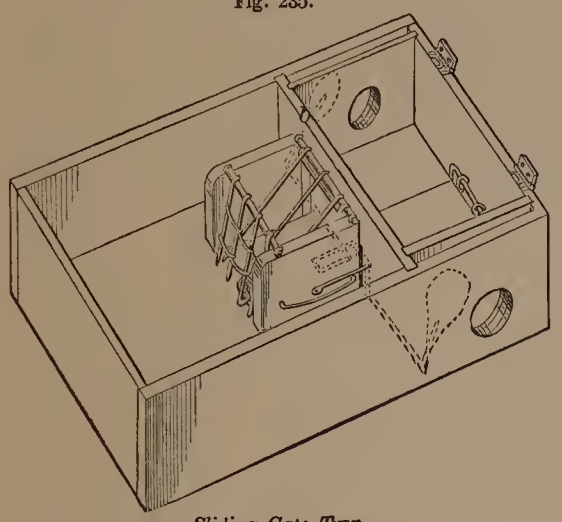


Falling-Door Trap.

Fig. 234 is open at both ends, when set, the doors *B* being supported by triggers. The animal standing on the platform *G*, to reach the bait on the hook, operates the rods *I*, *C*, and releases the doors, which fall simultaneously. This darkens the trap, and the animal lifts the grating *O* in passing to the light chamber *M*. The opening of the grating *O* resets the trap.

9. A *sliding-gate*. Of these there are several varieties. In Fig. 235 the animal passes through one of the holes into the first chamber. His weight

Fig. 235.

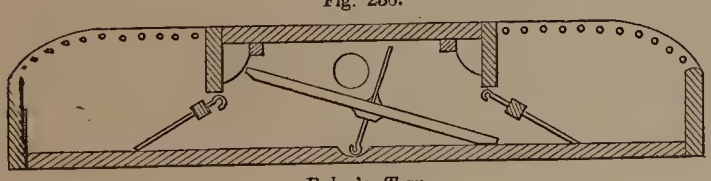


Sliding-Gate Trap.

on the platform brings the shutters over the holes and prevents his return. In passing through the grated door into the next chamber he resets the trap.

In Fig. 236 the box is provided at its center with an oscillating platform, to which is rigidly attached an upright leaf or partition of the same width, which has its openings for the entrance

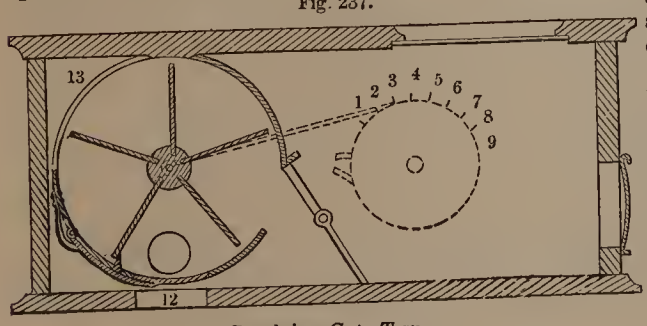
Fig. 236.



Baker's Trap.

of the animal so arranged that when it depresses the tilting platform by its weight, the said attached leaf or partition is thereby swung past said opening, leaving the opposite side of the platform in like manner open to admit the next visitor. The entrapped animal escapes on either side into a closed apartment.

Fig. 237.



Revolving-Gate Trap.

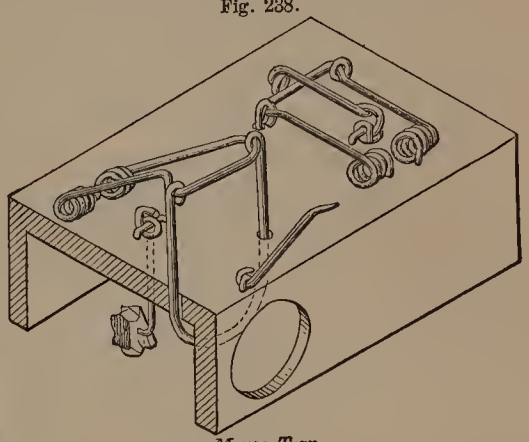
In another form the box forming the trap is provided with two apartments, separated in the usual way by a hinged grating, or self-closing door. In the first apartment is arranged a revolving shaft armed with vanes or paddles, and actuated by a spring. The animal, on entering this first apartment, releases by means of a treadle the detent of the revolving vanes, which press the said animal forward, causing him to enter the inner chamber, the said detent immediately checking the further revolution of the vanes. An index on the outside of the trap indicates, by the number of vanes released, the number of animals caught.

10. The *cage*. This class includes those in which an inverted wire basket is entered between a set of converging wires which oppose a return.

Sometimes this form of trap has a grated inclined door.

11. The *noose*. This is a very old form of snare, consisting of a running noose placed in the path of the animal. Such were the "*springes* to catch woodcocks," of old Polonius. They are used by poachers in England for snaring hares, and by boys for catching the less aristocratic rabbit.

Fig. 238.

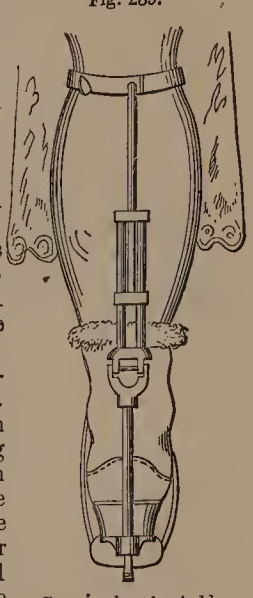


Mouse-Trap.

Among barbarous nations and frontiersmen a snare of this kind is attached to a sapling bent over and held by a trigger. The springing of the trigger releases the sapling, tightens the noose, and swings the animal clear of the ground.

The common mouse-trap is another form of the noose. A bow of spring wire is depressed at an opening, and the tampering with the bait allows the loop to spring up and strangle the animal against the top of the opening. (Fig. 238.)

Fig. 239.



Cunningham's Ankle-Supporter.

Anklets. CUNNINGHAM, March 20, 1866. The frame is made in three portions, reaching from a garter-band on the leg to the skate. The upper two portions are extensible on each other as the limb is flexed and extended, and the middle piece hinged to the lower

one to permit the said motion. It is intended to stiffen the ankle-joint and prevent the ankle turning sideways in skating.

The term is also applied to an article of dress which forms an extension above the top of the bootee or the shoe, and forms in some cases a protection for a weak ankle, in others is merely an ornamental extension.

Stockings, stiffened with steel springs or whalebones, worn as a protection to weak ankles, may also be termed anklets.

See GAITERS.

Annealing. Annealing is a process used in the manufacture of glass and iron for the purpose of rendering them less brittle. It is performed by allowing them to cool very gradually from a high heat, a sudden reduction of temperature rendering them hard and brittle. The singular properties of enameled glass are strikingly shown in Prince Rupert's drops and the Bologna vial. The former are prepared by allowing melted glass to drop into water, where the drops which are not broken by contact with the water form irregularly elongated globular bodies tapering to a tail at one extremity. These will bear a considerable blow on the thick end without breaking, but if a small piece be snapped off the tail the whole immediately falls into powder, emitting a cracking sound.

The Bologna vial is a rude flask of some three or four inches in length by about one in diameter, and from $\frac{1}{10}$ to $\frac{1}{8}$ of an inch in thickness.

If a leaden bullet be dropped into it from a height of three or four feet, or it be struck a smart blow on the outside with a stick, it will not break, but the dropping of a grain of sand or a small sharp fragment of flint into it will cause it to crack and fall to pieces.

Upon the proper annealing of glass much of its utility for many purposes entirely depends, and for vessels which are to be subjected to great extremes of heat and cold, careful annealing is absolutely indispensable. Its neglect is one of the principal causes of the breakage of so many lamp-chimneys, tumblers, etc., whose cost often forms such a considerable item in domestic expenditure. See GLASS.

Annealing is also a necessary process in the manufacture, by drawing, of wire and small tubing, as well as in making brass, copper, or sheet-iron vessels by hammering and rolling; the metal, by compression, becoming too hard and brittle for further reduction until annealed, after which it recovers its former softness and pliability.

When molten glass is allowed to cool slowly, its particles assume a fibrous arrangement, which imparts a certain elasticity to the whole mass, so that it can transmit vibrations from one extremity to the other. When suddenly cooled, the interior particles are enclosed by the solidification of the exterior before they have assumed the fibrous condition which insures the elastic structure or condition.

Glass may be annealed by placing it in tepid water, boiling it for a considerable length of time, and then allowing it to cool gradually.

Glass-ware is annealed by placing it, while yet hot, in an oven, technically called a *leer*, in which the glass is allowed to cool very gradually. A common form of the *leer* is a long oven, with sliding or travelling pans to hold the glass-ware, which enters at one end, as hot as it comes from the hands of the glass blower or presser, and by the gradual accession of pans of ware is pushed to the other end, whence it issues at a temperature which permits it to be handled. The particles of glass are supposed to assume a different structural relation, when thus slowly cooled, which favors their cohesion, and permits a certain degree of resiliency or elasticity. When cooled suddenly, there seems to be an inherent strain, a compulsory union, but faulty and fragile static condition, whose equilibrium is disturbed by an excitant in the form of a blow, which generates a tremulous motion among the particles, and permits them to yield to the disruptive force. This disruptive tendency may arise from want of homogeneity, unequal contraction, or something else.

In the annealing of metals, cast-iron for instance, the metal is brought to a red heat, and then allowed to cool slowly. The rationale of this process has been variously explained, and the most reasonable seems to be that the particles of metal take a different arrangement under these circumstances from that assumed by them when allowed to cool rapidly. In the latter case the exterior portion of the metal contracts first, and presses upon the interior portion, and the particles of the latter may thereby be compelled to take an arrangement which they would not were the cooling to take place at an equal rate in every part, and the process of cooling be long protracted. It does not seem to be determined whether the protraction of the process is merely necessary to insure an equal rate of cooling in every part, but it is not a violent conjecture that the said slowness may favor a particular aggregation of the particles, which gives them the greatest possible cohesion attainable with the structural nature of cast-iron. In making cast-iron malleable, as it is termed, a process much used in making builders' hardware, the metal is kept for several hours at a temperature a little below the fusing-point, and then allowed to cool slowly. From the prolongation of both stages of the process in this case, it is evident that the perfect result is best attained by giving the particles time, and not violently changing their structural relation; unless it be held that chemical changes in the furnace (such as parting with a portion of the carbon) have to be taken into consideration, and that the change is not all in the mechanical disposition of the particles. Tempering and annealing are nearly allied, but the processes are not confounded in the arts, owing to their different technical applications. The word "annealing" is derived from the Anglo-Saxon signifying to "kindle," and the heating is a necessary preliminary whether to withdraw the hardness incident to hammering and rolling of malleable metals, or the hardness incident to the rapid cooling of a casting in its mold. The protraction of the process of cooling the casting has a favorable effect upon its toughness and comparative softness. This is plainly seen by comparing them with chill-hardened articles, which are rendered hard and brittle by the sudden cooling.

Exposure of the hot steel to a cold surface renders it hard. This is usually done by dipping the red-hot metal in water, but other cold surfaces which are rapid conductors will answer the same purpose.

A thin, heated blade placed between the cold hammer and anvil is hardened by rapid cooling.

Thicker pieces, under the same circumstances, are somewhat hardened, but may be filed.

Placed on cold cinders, or other bad conductor, the steel cools more slowly and becomes softer.

Placed in hot cinders, and allowed to cool by their gradual extinction, it becomes still softer.

Encased in a close box with charcoal-powder, raised to a red heat, and allowed to cool very slowly, it reaches its softest state, except by a partial decomposition, as in the following process.

The steel is placed in a close box with iron turnings, filings, or scales, lime, or other matters, which will eliminate the carbon from the steel, and reduce it to the condition of pure, soft iron. This is the process used in softening plates and dies under the modern system of bank-note engraving invented by Jacob Perkins (cited below).

Analogous processes are had in the case of cast-iron, producing the various grades of hardness, from the chilled cast-iron to the soft malleable iron-castings.

The annealing of steel, to soften it for the uses of the die-sinker and engraver, is effected by heating it to a bright cherry red, and suffering it to cool gradually in a bed of charcoal. Another process, adopted by the writer, has been to imbed the steel blanks or forgings in lime within a cast-iron box. This is heated to redness in the fire, remaining a sufficient time to insure an equal heat of the articles inside; the box is then removed and buried in hot ashes, which protract the process of cooling for several days. See TEMPERING.

Perkins's process of transfer-engraving is as follows:—

A soft steel plate is first engraved in finished style, either by hand or mechanically, or the two combined, and the plate is then hardened. A decarbonized steel cylinder is next rolled over the hardened steel plate by powerful machinery until the engraved impression of the plate appears in relief upon the roller, the hollow lines of the plate being salient ridges on the cylinder. The roller is then reconverted to the condition of ordinary steel, and hardened, after which it serves for giving the intaglio impressions to any number of decarbonized plates, every one of which is an absolute counterpart of the original. Each plate when hardened will afford 150,000 impressions, and in the event of accident to the transfer-roller, any number of new rollers with the design in cameo may be obtained from the original plate.

The metallurgic process was explained by the inventor in the thirty-eighth volume of the Transactions of the Society of Arts. He there states that to decarbonize the plates they are placed in a vertical position in cast-iron boxes not less than three fourths of an inch thick, and surrounded on all sides by iron filings not less than one half an inch thick. The boxes are then placed in a furnace, and, after being heated, are allowed to cool in the most gradual manner by stopping off all the air-passages, and covering the boxes with a layer of cinders six or seven inches deep.

The plate or roller, as the case may be, having, in the softened state, received its impression, is reconverted in a similar box, wherein it is packed with sifted charcoal, made from leather scraps. After being heated in this cementing box and furnace from three to five hours, the plates or rollers are hardened by plunging vertically into cold water.

The use of steel plates for engraving has but comparatively lately superseded that of copper, and its peculiar value arises from the fact that by the processes of hardening and annealing it is made to assume the opposite conditions of extreme hardness and sufficient softness, so as in the former state to endure wear in printing, and also preserve the sharpness of its lines when enduring immense pressure against a soft steel roller or plate; and in the latter case to be readily cut by the graver or dry point, and have sufficient plasticity to yield to pressure, and insinuate itself into the finest lines of the hardened steel against which it is pressed.

The use of steel in preference to copper may be credited to Mr. Perkins and the engraver Warren. Warren annealed his plates at a high temperature in earthen boxes packed with pounded oyster-shells.

The practice in the Bank of England, as modified by Oldham, is to anneal at one time four cast-iron boxes, each containing from three to six steel plates, surrounded on all sides with fine charcoal, mixed with an equal quantity of chalk, and driven in hard.

The reverberatory furnace employed has a circular cast-iron plate or bed upon which the four boxes are fastened by wedges, and as the plate is slowly and continually revolved by power from the steam-engine which drives the printing-presses and other machinery of the building, the plates are exposed to an equal heat. When the required temperature is attained, all the apertures are carefully closed and luted to exclude the air and extend the cooling over at least forty-eight hours.

The surfaces of the cylinders and plates are thus rendered exceedingly soft to the depth of about $\frac{1}{32}$ of an inch, so as to be almost as impressible as lead and readily yield to the pressure of the transfer-press, where they are brought in contact with the counterpart portion, the softened cylinder with the hardened, originally engraved plate, or the softened plate with the hardened roller, whose design was received during the soft stage from the hardened plate, which had been engraved during *its* soft condition.

In some cases the extremely soft surface of the plates is planed off. In the Bank of England the plates are used for printing without previous hardening, as they can then be repaired, the parts brought up sharply by re-rolling under the transfer-roller. Danger of warping is also avoided.

Though belonging to the *hardening*, and not to the *annealing* process, it may here be mentioned, to complete the subject, that Oldham, Jr., has introduced a plan for precipitating the plates instantly into water, so as to prevent even an instantaneous exposure to the air; thus avoiding scale, or even a rough discoloration. See TEMPERING.

Many recipes are extant in the trade for annealing and hardening compounds; such are frequently heirlooms and preserved with jealous care. Lime and ox-gall are recommended by the operators in the English mint as an annealing composition.

For annealing of cast-iron, see MALLEABLE CAST-IRON.

Ede gives the following directions:—

"In the annealing of steel, the same care is required in the heating of it as there is in heating it for hardening, for overheating the steel is as injurious in one case as in the other. In the process of annealing, artists differ very much, some approving of heating the steel and burying it in lime, some of heating it and burying it in cast-iron borings, while others approve of heating it and burying it in sawdust. A far better plan is to put the steel into a box made for the purpose, and fill it with charcoal-dust, and plug the ends up so that the air is kept from the steel, then to put the box and its contents into the fire till it is heated thoroughly through, and the steel is at a low red heat; it must then be taken from the fire, and allowed to remain in the box, without opening the box till the steel is cold. Then when taken out the steel will be nice and clean and very soft, and without those bright spots which some mechanics call pins, and which are no small impediments to the filing and working of steel, and, in fact, the steel is believed to be improved by the process. A piece of stout gas-pipe, with a bottom welded in, and a plug made for the other end, makes a very good box for a small quantity of steel; but, for a large quantity, the box must be large in proportion. If the steel is very large, it is as well to make a char-

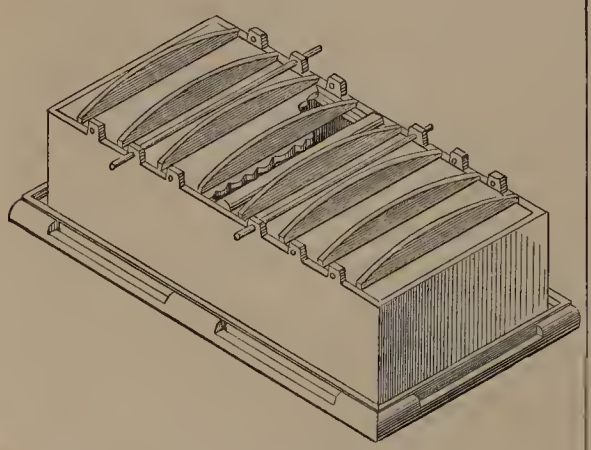
coal fire to heat it in, and then let the steel and the fire get cold together before it is taken out, and it will be equally soft. But it sometimes happens that a piece of steel is wanted in a hurry, and the steel, perhaps, is too hard to work on, and cannot wait for its being softened in a box; in such cases it may be heated in an open fire, and buried in charcoal-dust till it is cold, or if it be heated to a red heat sufficient to be seen in a dark place, and then plunged into cold water, it will work more pleasantly, but not so soft as if it were heated in a box with charcoal. There are many that do not know the value of a good tool, because the steel they work on has never been properly annealed, and before the tool has half done its duty it is worn out, or wants repairing; whereas, if the steel had been properly annealed, the same tool might have lasted ten times as long without repairing."

The process of annealing gongs, cymbals, bells, and mortars of bronze, is a complete inversion of the process cited above. The gong, for instance, which derives its name from the Chinese *tshoung*, a bell, is a compound of copper, 78; tin, 22. When cast, it is very brittle, from the quantity of tin, which is double the percentage of gun-metal (copper, 90; tin, 10), and between that and the proportions of speculum metal (copper, 43; tin, 20). The speculum metal is called by Ure the whitest, most brilliant, hardest, and most brittle of alloys. (Iridosmine is harder.) The gong when cast is as brittle as glass, but by being plunged at a cherry-red heat into cold water, and being confined between two disks of iron to keep it in shape, it becomes tough and malleable. Other bronze articles may be similarly tempered or annealed, as it has been variously termed.

There are several ways of hardening copper, — by the fumes of phosphorus, by an alloy of the latter, or some other metals, — but these render it brittle and destroy its usefulness for most purposes. In common with many others, Prescott regrets the loss, or rather our non-discovery, of the lost art of tempering bronze. After a careful examination of what has been written on the subject, the writer is inclined to the opinion that the hardness was imparted by judicious alloying with tin and iron, by the hammer, and by a careful use of the annealing process to confer toughness upon the back while the edge was allowed to maintain the hardness necessary for maintaining a sharp edge. See BRONZE; ALLOYS.

LEWIS'S ANNEALING BOX. The top, bottom, and sides consist of three separable pieces, to prevent warping by the heat of the annealing oven. The bottom forms a tray to receive the rectangular

Fig. 240.

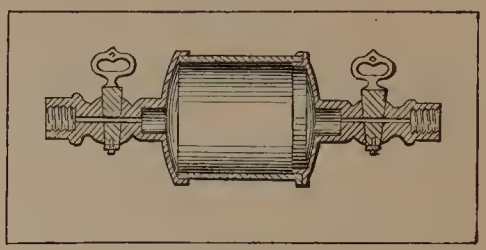


Lewis's Annealing Box.

frame forming the sides; the top is strengthened by ribs, rests on rabbets in the sides, and is fastened by transverse rods.

WASHBURN'S WIRE-ANNEALER. The wire is placed in a box, which is then charged with a gas which will not oxydize the wire when the latter is heated. This is for the purpose of preventing the formation of scale, and obviating the subsequent use of an acid

Fig. 241.

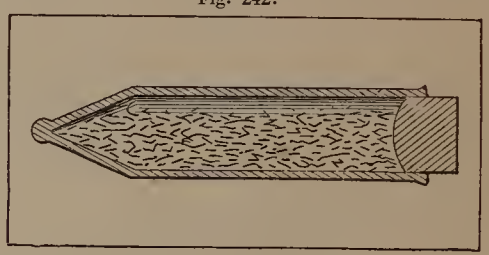


Washburn's Annealing Box.

bath to cleanse the wire. The vessel is provided with stopcocks by which the air in the interior is displaced and an artificial atmosphere or gas substituted. This is applicable to other articles besides wire.

MCCARTY, June 11, 1861. The device is intended for annealing cut-nails. The process consists in confining them in a suitable vessel, subjecting both

Fig. 242.



McCarty's Annealing Box.

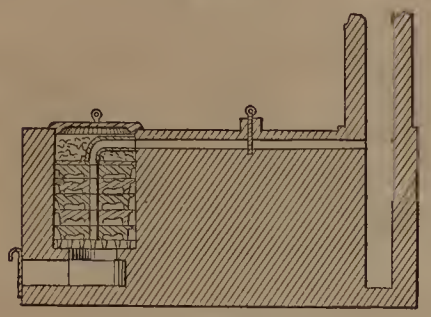
vessel and contents to a red heat, and allowing the whole to cool from six to twelve hours, according to the size of the nails and tube, and maintaining the vessel air-tight during the heating and cooling process.

Much attention has been directed to the annealing of cast-iron car-wheels. The object is to make the web soft and tough, so as to withstand the jar and strain incident to use, and at the same time have a hardened rim which will bear the wear.

WHITNEY, April 25, 1848, placed the wheels in a pile in a cylindrical pit or case in which they were closely covered and left to cool gradually. A non-conducting jacket protracted the period of cooling, and contributed to the effectiveness of the operation.

GEISSE, April 19, 1859. The wheels, while hot, are removed from the molds and piled in a cylindrical oven, where they are allowed to cool gradually. A blast of air is carried through the centers of the hubs, which, as the wheels are symmetrically piled, form a continuous air-duct, at the top of which is a conductor leading to the chimney. Dampers at the ash-pit and also in the chimney afford means for regulating the passage of air and thereby modifying the rate of cooling. By the means described, the wheels are induced to commence cooling at the centers, the cooling gradually extending outward. The heat at no time is sufficient to draw the chill which has been conferred upon them in the mold. The object is to prevent the hubs shrinking away from

Fig. 243.

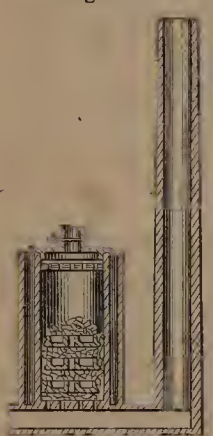


Geisse's Annealing Oven.

the rims after the latter have cooled, as is apt to be the case when the cooling is initiated in the reverse order.

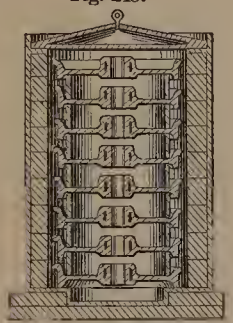
MOWRY, May 7, 1861. The car-wheels, alternating with layers of charcoal, are built up into a pile in a pit, which is so arranged that the quantity of air may be graduated to regulate the combustion, which is designed

Fig. 244.



Mowry's Car-Wheel Annealing.

Fig. 245.

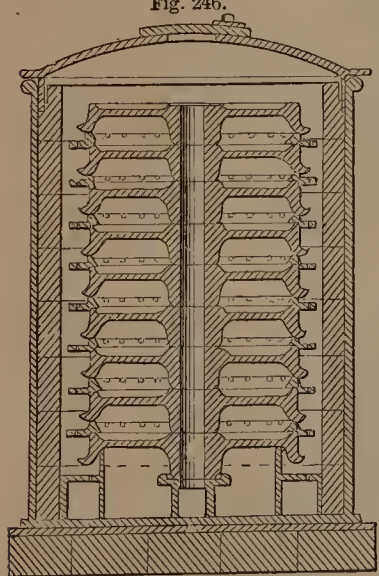


Moore's Car-Wheel Annealing.

to be protracted. The double walls of the pit or annealing case form a non-conductor to retain the heat, and allow but a very gradual cooling to the mass.

MOORE, December 5, 1865. The wheels are removed from the molds while hot, are piled one above another in a vertical pit, with intervening rings so placed as to separate the chilled tire from the web which is to be annealed. The interior space around the hubs is filled with charcoal, and the outside space around the tires is filled with sand. The charcoal, being ignited by the heat of the wheels, burns slowly, and anneals the web of the wheel, while the sand protects the tread from the same action, retaining the chilled surface which it has acquired in casting.

Fig. 246.



Moore's Car-Wheel Annealing.

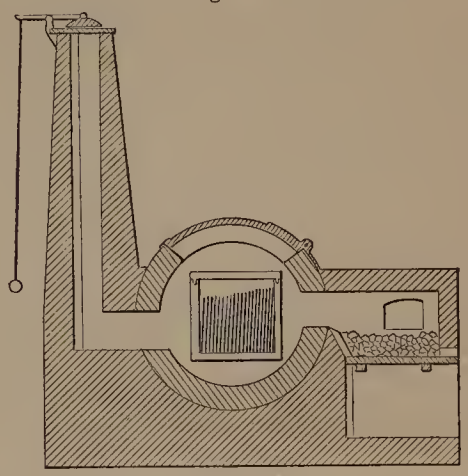
MOORE, October 9, 1866. This varies from the preceding in the mode of introducing the air-draft, and in the mode of isolating the tires.

The car-wheels are piled upon supporting rings at the bottom of the case, so that a passage is formed by the holes through the hubs for cold air, and another passage around the tread of the wheels for the draft for burning the charcoal, which is distributed upon the perforated flanges of the ring interposed between each wheel.

The openings in the base of the annealing case are the means of admission of atmospheric air to aid in the combustion, and this supply is graduated to suit the requirements of the case. Another opening admits air to pass upward through the hubs to cool them.

ELLS'S furnace for annealing and polishing sheet-iron. The sheets of metal to be operated on are placed in an iron box or muffle, with layers of oxide of iron, lime, and animal charcoal between them, heat-

Fig. 247.



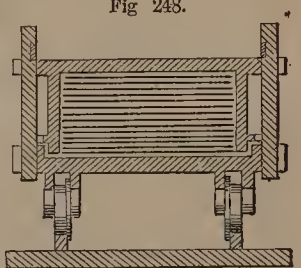
Ells's Annealing Furnace.

ing the whole to about eight hundred degrees in a suitable furnace, meanwhile subjecting the box to a rocking and rotating motion.

The attrition of the particles during the operations of heating and cooling is to give the peculiar mottled and polished appearance of Russia sheet-iron.

In WOOD'S annealing furnace, 1867, the box has track wheels. Its lower plate has an upwardly projecting rim to hold the sand used as luting. The top is a rectangular box, which is inverted over the pack of sheets, and is clamped at the bottom portion.

Fig 248.



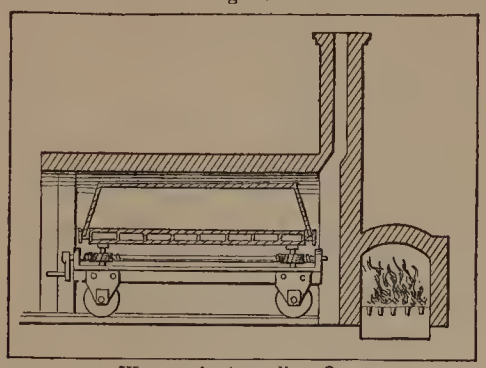
Wood's Annealing Furnace.

The plates are held in rigid compression between the wagon bottom and the inverted box; the object being to prevent discoloration. The truck has wheels by which it traverses on the railway, and is thus run in and out of the oven.

WORCESTER, September 25, 1860. This arrangement is intended to give a solid support to the bed-plate of the box which contains the pack of sheet-iron or the other iron articles which are to be annealed. When the carriage is run into the oven with its load, consisting of some tons of iron, if the bed-plate be supported in but a few places it is apt

to warp, which is destructive of the apparatus and injurious to the load then under treatment. In this

Fig. 249.



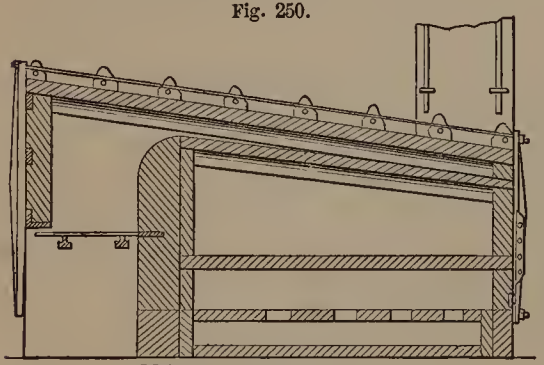
Worcester's Annealing Oven.

oven are dwarf-walls on the sides of the oven, below the level of the bed-plate of the box as it is run into the oven. After the box has reached its position longitudinally, the winch at the end of the carriage is turned and the bed lowered till it rests on the walls. A further turn or two of the winch lowers the supporting posts, so that they run clear of the bed-plate when the carriage is withdrawn. The withdrawal of the charge is the converse of the former action; the carriage being run beneath the bed-piece of the box, the winch is turned so that the posts elevate the bed-plate from the walls, and the carriage is then withdrawn with its load.

In WOOD's patent, July 9, 1867, the sheets are compressed between the top and bottom of the box, which are temporarily clamped together. The object is to prevent warping and discoloration.

MALONE, May 22, 1866. The furnace is at one end of the annealing chamber; the caloric passes along the

Fig. 250.



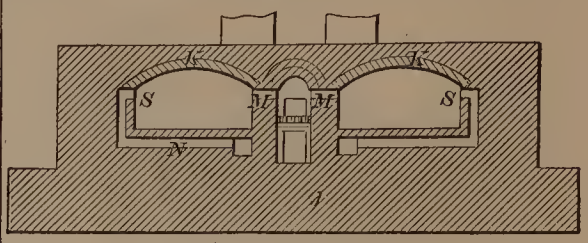
Malone's Annealing Furnace.

upper flue, dives down side flues to the lower flue, and thence passes by apertures and cross flues to the chimney. The object is an even heat at all parts.

REYNOLDS, February 13, 1866. This is an oven for decarbonizing and annealing iron. The caloric current from the furnace passes by the flues *M M*, beneath the arches *K K*, in the chambers, and thence by the diving-flues *S S*, and the lower flues *N*, to the chimney.

Annealing and tempering devices, especially intended for wire, and which act continually upon the wire as it passes through, will be considered under WIRE TEMPERING AND ANNEALING. As before remarked, annealing and tempering are nearly allied; the strictly tempering devices, however, are more conveniently considered under TEMPERING (which see), as they generally consist in means for giving peculiar grades of temper to axes, cutlery, scythes,

Fig. 251.



Reynolds's Annealing Furnace.

springs, etc., and in devices for securing the integrity of the articles under the great strain and change incident to the process.

An-neal'ing Arch. The oven in which glass-ware is allowed to cool gradually in order to anneal it. It is called a *leer* in some departments of glass-making.

The annealing arch of the plate-glass manufacture is called a *carquaise;* the front door, the *throat;* the back door, the *gueulette* (little throat); it is heated by a furnace along the side, called a *tisar*. The nomenclature is French, and indicates the source whence the manufacture was derived.

An-neal'ing Col'or. The color which steel takes in tempering or exposure to progressive heat.

An-neal'ing Fur'nace. A furnace in which metals are heated nearly to fluidity, and then allowed to cool slowly, so as to render them less brittle or to make them malleable.

Or, — as with glass, — a furnace in which the heat is retained for a considerable period in order that the process of cooling may be protracted. A glass-annealing furnace is called a *leer*.

Gold, silver, and zinc are occasionally annealed in the process of working, to render them more tractable. The process is of more especial and frequent application, however, to steel. See ANNEALING.

The annealing furnace for gold or silver in *fillets* or *planchets* has an iron table in front on which a cast-iron carriage is loaded with the metal in jointed and luted tubes; the car and its load are then run on to the floor of the furnace, and the door is lowered.

An-neal'ing Lamp. A dentist's appliance for heating foil used in filling excavations in carious teeth. It is a small alcohol lamp on a stand, and has a tray of mica or german-silver in which the foil is placed. The foil is more adhesive when warm.

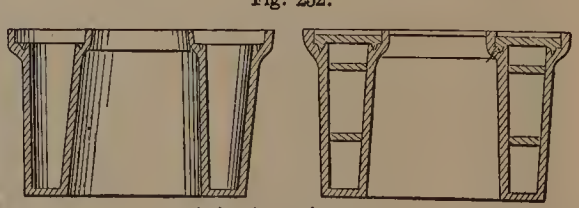
An-neal'ing Ov'en. A chamber in which articles are placed to allow them to cool gradually so as to make them tough. See ANNEALING.

The annealing arch for glass is called a *leer*.

An-neal'ing Pot. A closed pot set in a furnace, and used for exposing an object to heat without forming a scale of oxide.

Pots for annealing wire are made annular, so as to receive with as little vacant space as possible the wire which is coiled therein. The smaller the

Fig. 252.



Wire-Annealing Pot.

amount of air in the closed pot, the less the deterioration of the surface of the wire by exposure of its heated surface.

An-ni'hi-la-tor, Fire. An apparatus for extinguishing fire by the rapid production of carbonic-acid gas, which excludes the vital air from the combustible material. See FIRE ANNIHILATOR.

An'nu-lar Bit. A boring bit which cuts a circular channel, but does not *rout* the central portion.

Wads, buttons, and some other things, are made by a tool of this kind.

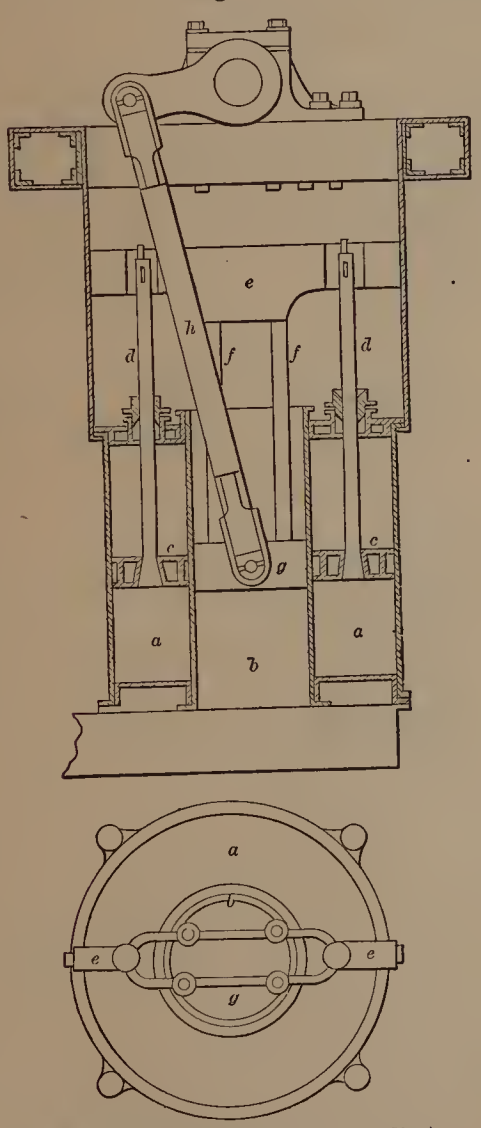
One form of the diamond drill makes an annular groove, leaving a central cylindrical plug of stone. See DIAMOND DRILL.

Several annular boring tools are described and illustrated under AUGER, which see.

An'nu-lar Bor'er. A description of rock-boring tool, in which a circular groove is made in the stone, leaving an axial stem of unbored matter. The tool descends until the stem is nearly as long as the wings of the tool; then, the latter being withdrawn, a grapnel is introduced into the hole, the stem broken off and raised. The borer is then relowered and the work proceeds. This mode of boring is convenient for affording a perfect section of the strata, giving, if care be taken, the dip as well as the quality. See ROCK-BORING TOOLS; GRAPNEL.

An'nu-lar-Cyl'in-der Steam'-en-gine. A form of *direct-acting steam-engine* invented by Maudslay, England, and patented by him in 1841. It consists of fixed inner and outer cylinders, between which is an annular steam space *a*, occupied by a piston *c*. This piston has two rods, *d d*, which pass through stuffing-boxes in the cylinder-head, and are keyed to the cross-head *e*. The latter connects by rods *f f* with the guide-block *g*, which reciprocates in the open-ended cylinder *b*. To a pin on the block *g* is attached the connecting-rod *h*, which passes to the crank on the paddle-shaft.

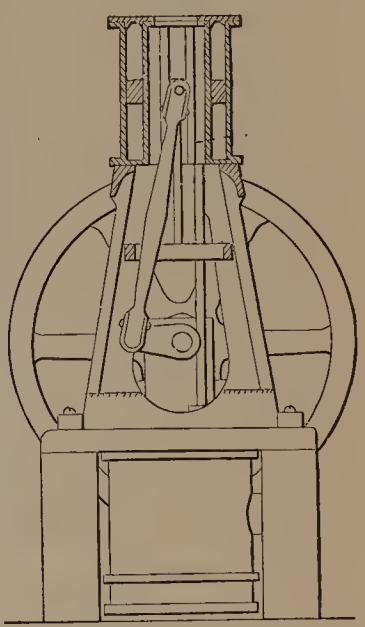
Fig. 253.



Maudslay's Annular-Cylinder Steam-Engine.

In another form of this engine the cylinder is annular and has two piston-rods which connect to a cross-head plate, slotted to permit the movement of the connecting-rod which passes through it. Rods pass up from this plate to an upper cross-head whose slides are within the annular cylinder. The connecting-rod passes from this cross-head to the wrist-pin of the crank.

Fig. 254.



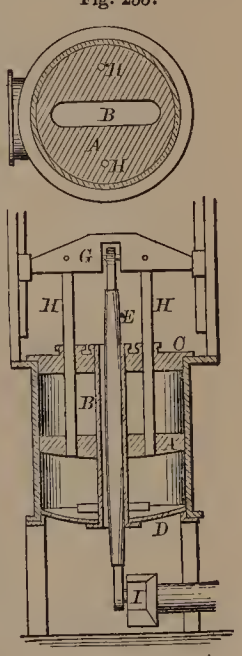
Annular-Cylinder Table Steam-Engine.

It may be necessary to remark that the Trunk Engine and the Annular-Piston Engine are distinct devices. There is a certain similarity of appearance, the inner and concentric cylinder, the most salient feature of novelty in appearance, being present in each engine.

In the *Annular-Cylinder Engine* both cylinders are fixed and the piston reciprocates in the annular intervening space.

In the *Trunk Engine* the annular piston is attached to the inner cylinder (the *trunk*) and reciprocates therewith; the latter slides in stuffing-boxes at the ends of the fixed outer cylinder. See TRUNK ENGINE.

Fig. 255.



Annular-Piston Engine

In another form of this description of engine the parts are somewhat modified. The two cylinder-heads are connected by a trunk which is of flattened form *B*, as shown in the plan. The piston *A* is of corresponding shape, and not strictly annular. It is connected by the rods *H H*, with the cross-head *G*, from which proceeds the connecting-rod *E* leading to the crank *I*. The rods *H H* pass through stuffing-boxes in the upper head *C*, and the trunk *B* connects the heads *C D*.

Perhaps the most gigantic steam-engines in the world are the three engines, the Leegh-

water, the Cruquius, and the Lynden, erected 1840–50, for the purpose of draining the Haarlem Lake. This had an area of 45,230 acres, and a maximum depth of seventeen feet below the level of the boezem, or catch-water basin, of the district. The boezem carries the collected waters to the sea, into which it discharges by sluices at Katwyk on the North Sea, and at Sparndam and Halfweg on the Y, or the Southern end of the Zuyder Zee. See *Koninklijk Institut van Ingenieurs*, 1857–9, *plaat* 3, 4.

Each of the three engines mentioned has two steam-cylinders placed concentrically, the one within the other, the outer of twelve feet diameter, and the inner one of seven feet diameter; both are secured to one bottom and covered by one cover, but the inner cylinder does not touch the cover within 1½ inches. There are two pistons, twenty-six inches deep, the compartments of which are fitted with cast-iron plates; the outer piston is annular, and has a packing on both sides; beneath this annular piston a constant vacuum is maintained when working. The two pistons are connected by five piston-rods to a great cross-head weighing about 190,000 pounds. Eight connecting-rods from the cross-head pass to the inner ends of eight working-beams, to whose outer ends the piston-rods of eight pumps are suspended. These pumps are situated in a circular series around the steam-engine, the working-beams radiating from an axis coinciding with a vertical prolongation of the cylinder piston-rod. (See DRAINING, for an illustration of the engine.)

The working of the engine is as follows: —

Steam is admitted below the central piston, and lifts it, the annular piston, the cross-head, and the inner ends of the pump-beams; causing the pump-piston to descend. A hydraulic apparatus is brought into action to maintain the parts in this position until the pump-valves have had time to change. The equilibrium-valve is then opened, the steam passes above both pistons and drives them down, the pressure being nearly equalized on the upper and lower sides of the small piston, while nearly two thirds of it acts on the upper side of the annular piston, which has a partial vacuum beneath it, to aid in the work. The effective stroke is also aided by the dead weight of the cross-head, which weighs over ninety tons, and by the weight of the pistons and rods of the engine.

Each engine has two air-pumps of forty inches diameter, and five feet stroke. The steam is cut off in the small cylinder at from one fourth to two thirds of its stroke, according to the load, and is then farther expanded in the large cylinder.

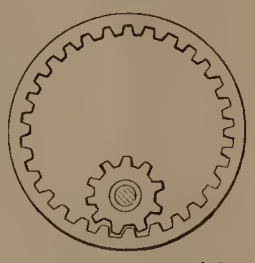
When working with the net power of 350 horses, the average consumption is 2¼ pounds of Welch coal per horse-power per hour, or 75,000,000 pounds of water raised one foot high with 94 pounds of coal. The duty of the engines has been as high as 87,000,000. See DUTY.

The Lynden and Cruquius engines work eight pumps, each of seventy-three inches diameter and ten feet stroke. The Leeghwater works eleven pumps of sixty-three inches diameter, ten feet stroke, each engine being calculated to lift sixty-six cubic meters of water per stroke.

The three engines are capable of discharging 2,000,000 tons of water in twenty-four hours at their full depth. They were erected by two English companies.

An'nu-lar Gear'-Wheel. A wheel whose teeth are on the concavity of an annulus, or ring, which is destituteof web or spokes.

Fig. 256.



Annular Wheel and Pinion.

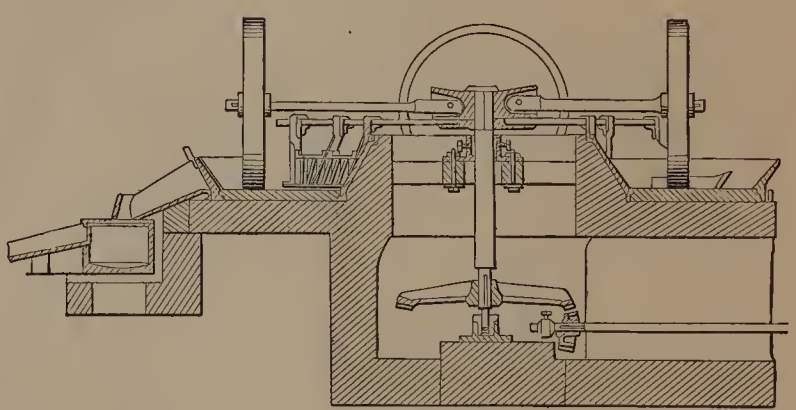
An'nu-lar Mi-crom'e-ter. A form of the circular micrometer invented by Fraunhofer of Mnuich, consisting of an annular glass disk whose central aperture is about half an inch in diameter and bounded by a metallic ring which is cemented to the inner edge of the glass.

The metallic ring is used to determine differences of declination between stars, from the differences of time occupied by them in traversing different chords of the ring. See CIRCULAR MICROMETER.

An'nu-lar Pan. A ring-shaped trough in which the vertical grinding-wheels of an ore-crusher revolve.

The main shaft may stand in a central aperture of the bed and receive motion from a horizontal shaft beneath. The pulverized ore, mixed with water, is loosened up by rakes, and scraped from the sides to the wheel-tracks by knives. The wheels follow different tracks.

Fig. 257.



Annular Pan.

The pan form of amalgamator is a favorite, and several illustrations may be seen under AMALGAMATOR, Figs. 144–153, pp. 78–81.

An'nu-lar Saw. The annular saw for cutting pearl-button blanks is a steel tube with a serrated end.

The annular saw of the surgeon is the *trepan*, or, preferably, the *trephine*; which see. Other varieties of annular saws are known as *crown*, *barrel*, *drum*, or *cylinder* saws; which see.

An'nu-lar Valve. A gravitating-plate valve of a circular form and with a circular central aperture. It works upon a stem by the upward pressure of water, and closes an annular aperture when the lifting force is removed. See illustration in SCREW-PROPELLER STEAM-ENGINE.

An'nu-lat-ed Col'umn. A clustered column girt by bands.

An'nu-let. A flat molding; a small square member in the Doric capital.

An-nun'ci-a-tor. Annunciators are substitutes

for the old-fashioned arrangement of bells in hotels, etc. Instead of each room being connected to a separate bell in the office of the hotel, the bell-pull of each room is connected to a single bell, which gives notice to the clerk or porter, and at the same time a pendulum with the number of the room is caused to vibrate, or the shield is removed from a number corresponding to that of the room. The devices are various. The general scheme is to connect the wire from the room to a numbered plate, which is moved up to an opening and thereby exposes its number to view. The wire at the same time trips a trigger which actuates the hammer of the bell. A variation in the mode of operation is found in those annunciators whose openings are all covered by pivoted shields, the numbers being permanently attached in the rear. The motion of the wire trips the sounding-hammer as before, and at the same time trips the shield to which it belongs, and causes it to oscillate from before the opening and expose the number to which it belongs. A crank operated by the hotel clerk restores the normal condition after the number has been observed.

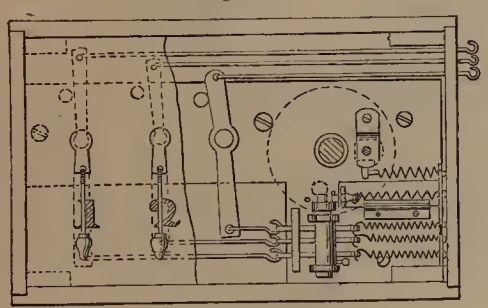
Horsfall, October 4, 1853, and Hale, April 22, 1856, are among the earlier inventors.

In Horsfall's, the wire from the room operates a rod whose horizontal lifting and tripping arm extends beneath its appropriate swinging index-plate. The rod and arm are arranged in such relation to the rocking-frame which carries the alarm-bell, that, as either of the rods is raised for the purpose of tripping one of the index-plates and exposing its number to view, the frame and bell will be also raised, and the pendulous hammer allowed to descend some distance. When the rod descends after tripping the index-plate, the rocking frame and bell also descend, and the contact of the short arm of the hammer with a lever causes the hammer to sound the alarm, subsequent to the exposure of the number.

The index-plates are thrown back to their covering position by an eccentric rod and connecting devices.

In the example annexed, a crank arm is attached to the center of the lever, and is acted

Fig. 258.

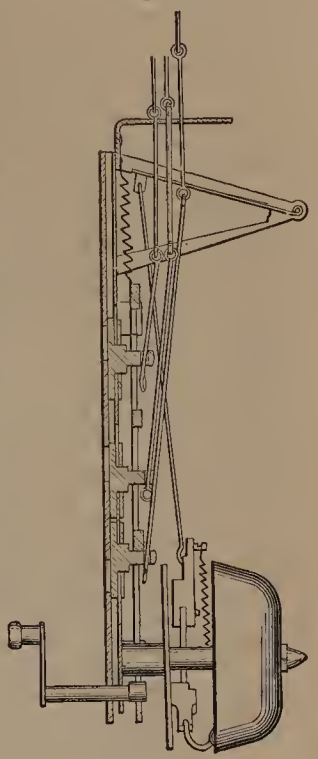


Hotel Annunciator.

upon by the wire, carrying a pendulum in front of the face of the annunciator, and by its vibration denoting the wire acted upon and the number of the room.

In Fig. 259 the annunciator is so arranged that the lifting of any wire shall not alone expose the number of the apartment, but shall lift a plate, and through the connecting wire cause the hammer to strike upon the bell. The slides, with the numbers upon their faces, have projections on their rear with holes through which the wires pass, and the upward movement of the slides is limited by transverse bars above them, which cross the line of their motion.

Fig. 259.

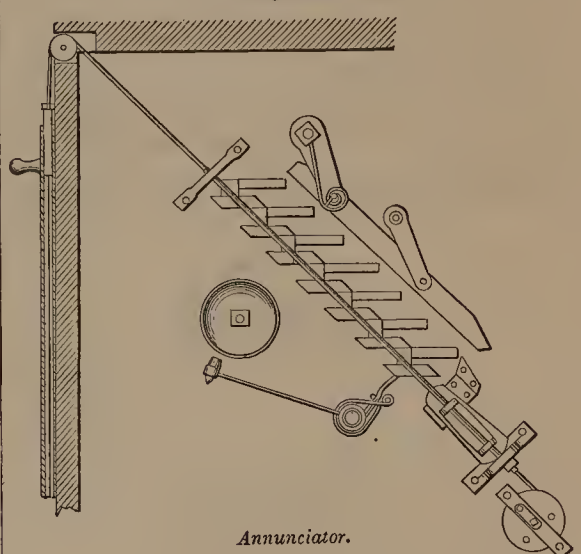


Annunciator.

The mechanism in Fig. 260 is so arranged and connected with a knob in the room of a hotel, that as the knob is actuated by the occupant a bell will be sounded at the office, and a slide moved which discloses the name of the article wanted, such as "water," "boots," "messenger," etc. A slide in the room is made to cover the names of articles generally wanted by a guest, and corresponds with a similar slide and names in the office. The extent of the pull determines what name shall be exposed, and the guest, by noticing the effect at the *pull* end, may determine the effect at the other end, as the slides are coincident.

Another form is a combined hydraulic and pneu-

Fig. 260.



Annunciator.

matic annunciator. The chamber of the guest and the hotel office are each provided with an indexed gage, consisting of a hollow tube containing a colored liquid. At the back of each tube is a graduated index marked at intervals, "fire," "light," "water," "brandy," "towels," etc., as may suit the average of customers. The respective tubes are connected by an air-pipe, into which air is injected by the guest, to raise the liquid in the respective tubes to the point which indicates his wants.

An'ode. That pole of the galvanic battery by which the electricity *enters into* the substance suffering decomposition; the positive or + pole. This nomenclature was adopted by Professor Faraday.

A-nor'tho-scope. The name given by M. Plateau of Brussels to an instrument invented by him and intended to produce a peculiar kind of anamorphosis by means of two disks rotating rapidly one before the other; the hinder one is transparent and bears distorted figures, while the front one is opaque and is pierced with a number of narrow slits. On revolving the disk the distortions appear as amusing and interesting figures and pictures. As in other toys of a similar kind, the effect depends upon the persistence of impressions on the retina. — *Brande.* It probably suggested the *Zoetrope*, which has lately become so popular in the United States. See THAUMATROPE; PHENAKISTOSCOPE; STROBOSCOPE.

An'sæ. (*Artillery.*) The handles of some kinds of brass ordnance.

An'ta. (*Architecture.*) A pilaster occurring at the corner of a flank wall.

An'te-fix'æ. (*Architecture.*) *a.* Ornaments placed below the eaves of a Grecian temple; perforated to allow the escape of water from the roof.

b. Blocks covering the termination of the ridge formed by the overlap of the tiles on a Grecian roof.

An'te-mu'ral. (*Fortification.*) An outwork consisting of a high, strong wall with turrets, for the defence of a gate.

An-ter'i-des. Buttresses.

An'te-so-la'ri-um. A balcony facing the sun.

An-te-ven'na. An awning, or shade roof.

An'tho-type. A photographic process in which the colored juices of the wild poppy, rose, stock, etc., are effaced by the action of light.

An'thra-cene. A solid crystalline hydrocarbon, accompanying naphthaline in the distillation of coal-tar.

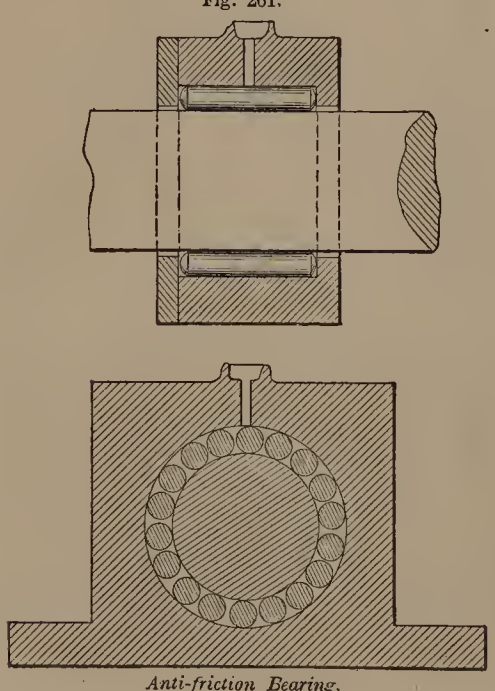
An-thra-com'e-ter. An instrument for measuring the amount of carbon in a given case. — *Beil.*

An'ti-at-tri'tion Com'pound. For the bearings of machinery and axles of carriages. See LUBRICANT; ALLOY; ANTI-FRICTION COMPOSITION; ANTI-FRICTION METALS.

An'ti-cli'nal Line. (*Mining Engineering.*) The axis of curvature on the arch or saddle of a range, on each side of which the strata dip. Opposed to *Synclinal.*

An'ti-fric'tion Bear'ing. A rolling bearing for an axle or gudgeon. The intention is that the parts primarily in contact shall not rub against each other, but move in unison. In one form the roller surfaces impinge upon the surfaces of the axle and its box (Fig. 261); in another form the rollers are on axles (see Fig. 263). A familiar illustration is also found in the improved form of hanging grindstones (see Fig. 265).

Fig. 261.

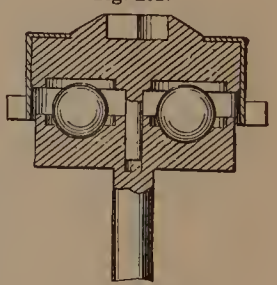


Anti-friction Bearing.

The "Palier Glissant," of Girard, consists of a journal box whose lower part is grooved and has an aperture communicating with a pipe through which water under a heavy pressure is introduced beneath the journal. The effect of this is to slightly lift the journal, allowing a very thin film of water to escape, which effectually lubricates the bearing, entirely preventing contact of the metallic surfaces.

This is analogous to the hydraulic pivot for turbine wheels, invented by the same engineer, in which the weight of the turbine and its vertical shaft is supported by a water cushion, in the same manner as is the horizontal axis in the former case.

Fig. 262.



Anti-friction Box.

An'ti-fric'tion Box. An enclosure for the balls or rollers of a step or bearing.

An'ti-fric'tion Compo-si'tion. A lubricating material or compound to diminish friction of parts moving in contact. The compounds are numerous, and include the following materials in various combinations: —

Alloys. See ANTI-FRICTION METALS.	Mucilage.
Alum.	Oils of various kinds.
Asbestus.	Pasteboard saturated with petroleum.
Bitumen.	Pith.
Borings of Metal.	Plumbago.
Cork.	Sal-ammoniac.
Cotton.	Shavings of wood.
Fiber, Animal.	Silicate of soda.
Fiber, Vegetable.	Steatite.
Gelatine.	Sulphur.
Graphite.	Talc.
Gum.	Tallow.
Gypsum.	Tannic acid.
Lard.	Wood saturated with oil.
Lime.	Wool flock.

An'ti-fric'tion Met'als. Alloys principally used for bearings of machinery and for journal boxes. Several are described under the head of ALLOY.

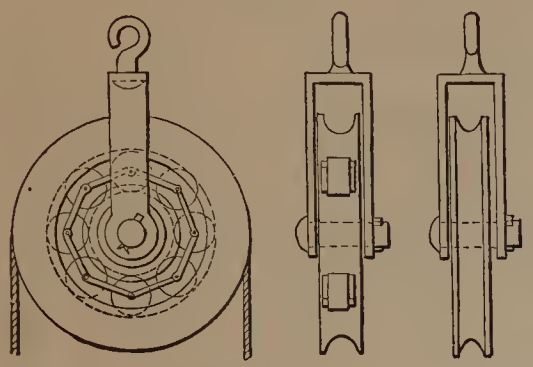
Some variations are found in the formulas, comparatively few agreeing even in the composition of Babbitt's metal, patented in 1839, and so much used throughout this country and in Europe. The following table will give the composition of several: —

	Tin.	Antimony.	Copper.	Zinc.	Lead.	Iron.	Arsenic.	Glass.	Borax.	Sulphur.	Pruss. Potassa
Babbitt's	50	5	1								
Another formula	10	2	1								
Fenton's	10		10	10							
Belgian, for objects exposed to friction	4	0.5	20		0.25						
" exposed to shocks	1		20	6							
" exposed to heat	0.5		17	1	0 25						
Dinsman's			16		8			4	1		0.5
Richardson's	2		62	34		1	1				
Strubing's	18	2.5		75	4.5						
Engl. Pat. 896 of 1862	40		28	136		2	1			1.5	

An'ti-fric'tion Press. A press in which the power is obtained by the rolling of two cams against an intermediate roller. See ROLLING-CAM PRESS.

An'ti-fric'tion Pul'ley. A device for the purpose of lessening the friction of the sheave on its pin. An annular system of anti-friction rollers surround the pin, and rotate on their own axes as they revolve on the pin. They are maintained at their

Fig. 263.

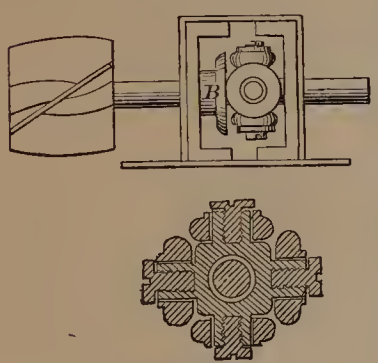


Anti-friction Pulleys.

proper relative distances by a ring or series of links, so that the faces of the rollers themselves do not come in contact, as contacting faces, under these circumstances, would be revolving in different directions, and great friction would result.

An'ti-fric'tion Step. A bearing at the end of a rotating shaft, to diminish the friction of the contact with the step when pressure is applied longitudinally. In the step for propeller shafts, the loose collar *B* has anti-friction wheels on radial axes, which act between a collar on the propeller shaft and a fixed plate traversed by said shaft. The object is an anti-friction bearing to take the *end* strain of the shaft.

Fig 264.



Anti-friction Step.

A somewhat similar arrangement is used for vertical shafts in some cases. See Fig. 262.

An'ti-fric'tion Wheel. The wheels *C C'* form a rolling bearing for a shaft, so as to diminish its friction thereon; the bearings for the axis of a grindstone, for instance, as shown in Fig. 265. Analogous devices are found in many machines and in carriages. See JOURNAL BEARINGS; AXLE.

An'ti-gug'gler. A small tube, inserted into the mouth of a bottle or carboy to admit air while the liquid is running out, and thereby prevent guggling or splashing of corrosive liquid.

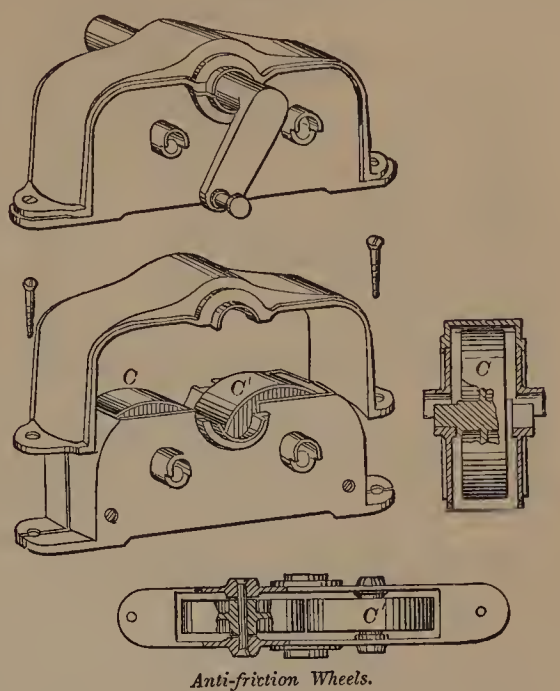
An'ti-in'crus'ta-tor. A device or a composition to prevent the incrustation of steam-boilers.

One class of improvements in this line is magnetic; it depends upon keeping up an electric action which prevents the adherence of the scale of salts of lime, etc.

Another class consists of mechanical agents, and a third of chemical. See INCRUSTATION IN BOILERS.

An-tim'e-ter. An optical instrument for measuring angles. A modification of Hadley's Quadrant, long since superseded by superior instruments.

Fig. 265.



Anti-friction Wheels.

An'ti-mo-ny. Equivalent, 129.03. (Symbol, Sb: Stibium.) Specific gravity, 6.8. Melts at 995.5, Fah.; passes off in vapor at a white heat. It has a peculiar taste and smell. It is a bluish-white, brittle metal, and is much used in hardening type-metal, to which it also imparts the faculty of not shrinking in cooling. It enters into the composition of some other alloys, such as one kind of speculum metal.

Its salts are much used in medicine and pyrotechnics.

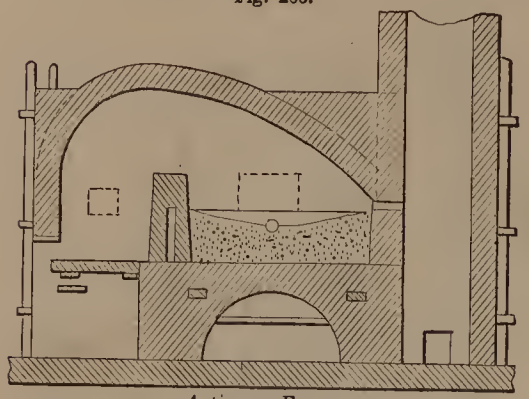
Antimony was known to the Hebrews as a cosmetic. With it, it is supposed that the wicked Jezebel painted her eyelids and eyebrows, B. C. 884, just before she was thrown out of window by the orders of the cruel Jehu, who trod her under the feet of his horse, and left her to be devoured by dogs.

The Arab women use *kohl* to increase the brilliancy of the expression of their eyes, as the Hebrew women did down to the times of Jeremiah and Ezekiel, and later. It is yet an Oriental custom. Little toilet boxes and bottles for kohl are found among the relics of the ancient Egyptians, and are preserved in many collections; for instance, in the Abbott Collection in the possession of the Historical Society of New York.

Basil Valentine introduced the metal antimony into the practice of medicine. Observing that some swine fattened surprisingly quick after the administration of the drug, he tried it on some of the monks in his vicinity, who had become much attenuated by their Lenten fast. The account says that they were all killed, and hence the name *Anti-moine*. It was previously called *Stibium*, and yet retains that title in scientific nomenclature.

An'ti-mo-ny Fur'nace. The antimony furnace, Fig. 266, as at present used, is a reverberatory whose hearth is formed of clay and sand solidly rammed together and sloping from all sides towards the middle, at which place is the discharge opening, temporarily closed with coal-ashes. The air channel passes up through the fire-bridge, and the fire

Fig. 266.

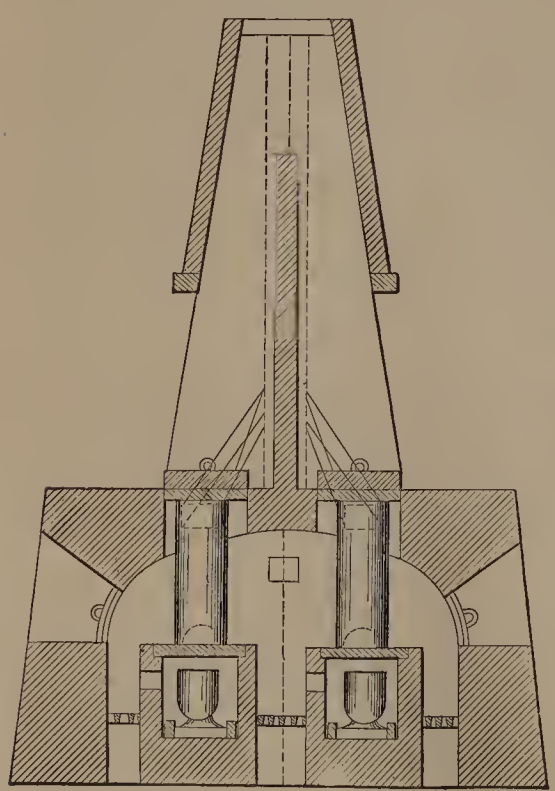


Antimony Furnace.

is in the chamber at the end, the flame reverberating in the chamber above the ore. The charge is introduced at the usual opening, which is closed by a door while the operation is in progress. The slag is drawn off at the same opening. The sulphuret of antimony is found associated with gangues of quartz, sulphate of barytes, and carbonate of lime, and is easily fused therefrom by the application of heat in the furnace described. It is not obtained perfectly pure therefrom, but is fused again under coal-dust in crucibles on a reverberatory hearth.

The former mode of obtaining the metal from the ore consisted in exposing it in luted crucibles which are placed in a furnace (Fig. 267). The crucibles have openings in the bottom, and are luted to a

Fig. 267.



Antimony Crucible.

perforated tile which forms the roof of a lower chamber containing a pot into which the metal escapes as the operation proceeds. The gangue remains in the crucible above. This method is found to be very destructive of crucibles.

The crude antimony is purified by repeated exposure at moderate heats to expel the sulphur and fuse the metal. The difficulty in the treatment arises from the volatility of the metal, which escapes if excess of heat be applied. This is in the domain of chemistry.

The ordinary alloys of antimony are : —

	Antimony.	Lead.	Tin.	Copper.	Bismuth.
Type Metal	1	4			
Stereotype Metal	1	6			
Music Plates	1	1	1		
Britannia Metal	8		100	2	2
Pewter	1		12		

An'ti-qua'ri-an. A size of drawing-paper measuring $52\frac{1}{2} \times 30\frac{1}{2}$ inches, and weighing 233 pounds to the ream.

An-tique' [an-teek']. (*Type.*) A fancy style in which each stroke of the face has an equal thickness. There are many varieties.

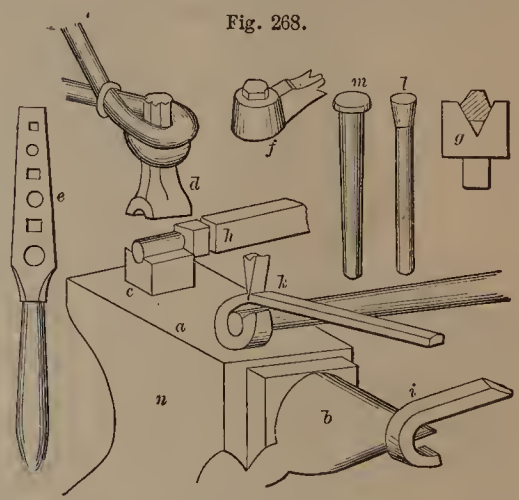
An'ti-sep'tic. See WOOD, PRESERVATION OF; FOOD, PRESERVATION OF.

An'vil. (*Forging.*) 1. This is ordinarily a mass of iron which sustains a piece of metal while the latter is being forged to shape. In its ordinary form, where the hammer is worked by hand, it has a square central block, and a strong, projecting, and pointed piece of steel called the *beak* or *horn*. The *quarter* has holes for tools such as cutters and swages, and the whole is mounted on a block. Isaiah speaks (xli. 7) of him that smites the anvil in connection with the art of the goldsmith, and also refers to the subsequent soldering.

In heavy operations, such as the forgings of heavy ordnance and shafting, the anvil consists of an enormous iron block imbedded to a considerable depth and founded on piles or masonry.

Fig. 268 shows the ordinary blacksmith's anvil,

Fig. 268.



Anvil and Tools.

and illustrates the methods of making bolts.

a face of the anvil.
b horn or beak.
c hardy hole, with rounding-iron inserted.
n body or web of the anvil.

In forming a bolt by the *drawing-down process*, the size of the bar of iron is reduced at proper intervals by fullers, and the operation is completed by the rounding-irons, shown at *c* and *d*, leaving the head of the full size of the bar *h*, which is then cut off with a chisel.

In *upsetting*, the body of the bolt remains of the full size of the bar, while the head is enlarged by

upsetting, that is, driving the end down upon the body with a hammer, thus forming an enlargement; or it is enlarged by *jumping*, that is, beating the heated end forcibly on the anvil; in either case, the head of the bolt is finished by means of the heading-tool, two varieties of which are shown at *e* and *f*.

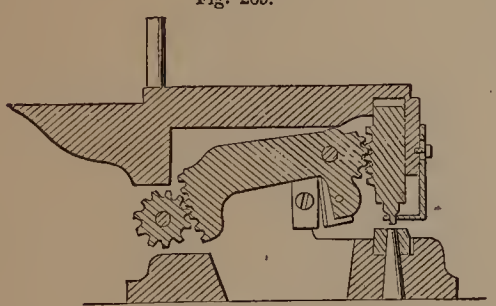
The third process of bolt-making is by welding or *building up;* a bar of flat iron is bent around the horn of the anvil, as shown at *i*, and the bar of round iron intended to form the body is inserted through it; the ring is then cut off at the proper length by the chisel, shown at *k*, and the head finished as usual. *g* is a swage for forming hexagonal heads to bolts, or other hexagonal or triangular forms, and *l*, *m*, represent bolts. in the first of which the head is partially made, and in the latter completed.

Tubal Cain, the descendant in the sixth generation of Cain, is the first recorded blacksmith, and the necessities of his craft must have introduced the anvil before the time of Cinyra of Cyprus, who is credited with the invention by Pliny.

The anvil of the Greeks and Romans (*incus*) was usually of bronze, and was shaped like our own. It had a horn, and was mounted on a wooden block.

Among numerous varieties of anvils for special trades, and to give a more extended usefulness to the space occupied by the implement, may be cited one in which a shears and punching-machine are com-

Fig. 269.

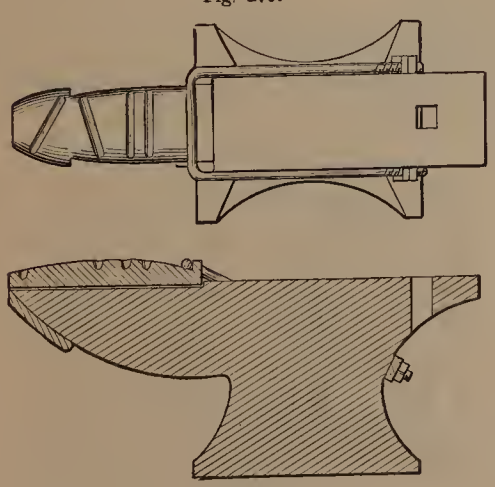


Anvil Shears and Punch.

pactly placed beneath the anvil, and are worked by handcrank, pinions, and segment-rack.

Another anvil has a secondary horn, is socketed upon the beak of the anvil, and confined there by a hinged link. On the upper surface of the secondary horn are grooves into which the shoe is driven

Fig. 270.

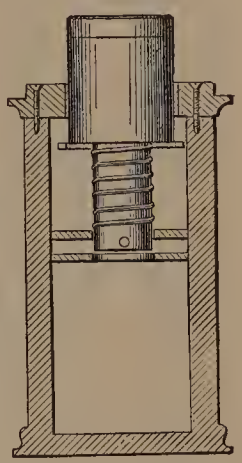


Anvil.

sc as to bevel the inner edge, to facilitate its freeing itself from snow which becomes packed inside it.

In Fig. 271 the anvil is supported by a stout spring, whose recoil is partially counteracted by the light springs above. The object is a certain amount of resiliency without jar as the anvil regains its normal position.

Fig. 271.



Spring Anvil.

The gold-beater's anvil, when using the forging-hammer, is a block of steel, four inches long, and three broad. The *ingot* is reduced by this operation to a thickness of one sixth of an inch.

The anvil used in the subsequent operation is a block of black marble twelve inches square at top, and eighteen inches deep, framed in a wooden block.

Anvils are tempered in a *float*, instead of being merely dipped. The rapid formation of steam keeps the water from close contact with the metal, and in the *float* a copious stream of water is poured upon the surface to be hardened, falling particularly upon the center of the face.

Large anvils are slung from a crane into a tank beneath a fall of water, where they are hardened; being lifted before the main bulk of the iron is cooled, the remaining heat is allowed to draw the temper to the right degree, when the anvil is instantly immersed.

The casting of an anvil weighing 358,000 pounds is thus described by the "London Engineer": —

"Another immense casting has been turned out by the Midland Works, Sheffield, viz. a 160-ton anvil-block for a steam-hammer. In the center of the floor a great pit was dug, and in this the mold was formed, the anvil being cast with its face downward. The mold was 12 feet square at the base, and 11 feet 6 inches deep, and it was estimated that nearly 170 tons of iron would be required to fill it. At intervals outside the shop were five furnaces, and at six o'clock in the morning these commenced to pour their molten contents into the huge chasm, and continued until about five o'clock, when the operation was declared to be successfully completed. From four or five different points streams of liquid fire were slowly rolling to the edge of the pit, where they fell amidst showers of starry sparks into the vast mass beneath. A metallic rod was thrust through the mass to test its perfect liquidity, and, this having been satisfactorily proved, the top of the pit was carefully closed, to be opened no more until the metal has cooled, which will probably be in about seven weeks. The anvil is intended to be placed in a gun-manufactory in the vicinity. The bed consists of a first course of great piles, which have been driven by steam-power 15 feet into the solid ground. Upon these is a thick bulk of oak, solidly braced and bolted together, and the combined mass forms the bed of the anvil. Only about half a foot of its bulk will appear above ground. The block will have to sustain the blows of a 25-ton steam-hammer which will be employed in forging 600-pounder and 300-pounder guns for Mr. Whitworth."

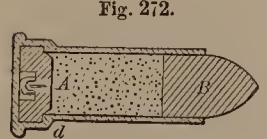
Mr. Ireland, of Manchester, England, has a portable plant for casting large anvil-blocks in the posi-

tion they are to occupy on the premises where they are to be used. He furnishes everything but the iron and the blast.

"The plant used at Mr. Bessemer's works consisted simply of a cupola 4 feet in diameter within the lining, and 12 feet deep to the charging-door, constructed on the "upper tweer" principle. A belt about 2 feet 9 inches deep surrounds the cylinder at about 7 feet from the ground, and into this belt the blast is delivered by two large pipes, one on either side. The upper row of tweers consists of sixteen orifices, each about 3 inches in diameter, ranged equidistantly above the level of the main supply pipes, which discharge into the lower portions of the belt. The lower tweers are only four in number, each about 8 inches in diameter, disposed opposite each other, but not opposite the main pipes. By this means the blast is very equally distributed through all the tweers. At the time of our visit, this cupola was bringing down 9 or 10 tons of iron per hour, and Mr. Ireland has recently cast an anvil-block, weighing no less than 205 tons, at the Bolton Iron and Steel Works, at the rate of 25 tons per hour, with two cupolas precisely similar to the one under consideration. The consumption of coke is very moderate, when once everything is well warmed up, not greatly exceeding one cwt. of coke per ton of iron. A strange contrast exists between such operations as this and those in which Mr. Ireland first engaged in the year 1809, when he, in common with many other founders, considered it a good day's work to melt a single ton of iron in ten hours.

"It is not easy to see how the casting of large masses can be more economically effected than under this system. The lining of the cupola being removed, it is brought into the condition of an ordinary boiler shell of no very excessive weight, easily admitting of transport by either rail or water. The whole affair being carried out by contract, the manufacturer is saved an immense amount of trouble and responsibility, while all the operations being conducted by those who possess a special knowledge and experience of the matter in hand, the best results are sure to be obtained at the least possible outlay. In many cases, without the existence of such a system, the manufacturer would find himself compelled to erect a cupola of large dimensions for which, the block once cast, he would have no further use." — *London Engineer*.

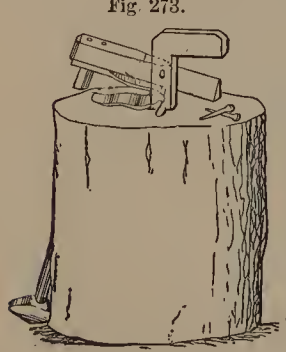
Fig. 272.



Cartridge Anvil.

2. In the Laidley cartridge (Fig. 272) is an *anvil*-plate *A* which is held in position by a shoulder *d* on the capsule. On the plate is a nipple which holds the percussion-cap, and the latter is exploded by a blow on the rear, delivered by the nose of the gun-lock. *B* is the bullet retained by spinning down the edge of the capsule.

Fig. 273.



Anvil-Cutter.

3. A little pennon on the end of a lance.

An'vil-cut'ter. A shears operated by a blow of a hammer, for the use of blacksmiths.

The lower cutter is upon one end of a lever whose other end is elevated by a spring to open the jaws. The jaws are closed by a blow of the hammer upon the other end of the lever.

A-or'tic Com-press'or. An instrument for compressing the aorta to limit the flow of blood from thence to the divided femoral artery in cases of amputation at the hip joint. See *Surgeon-General Barnes's Report, Circular No. 7.*

Ap'er-ture. 1. (*Architecture.*) An opening in a wall or partition, for a window, door, ventilation, or to form a recess.

The sides are *jambs.*

The top is the *head,* or *lintel.*

The bottom is the *sill,* or *threshold.*

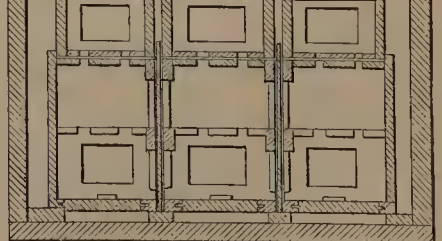
2. (*Optics.*) The orifice in the end of a telescope or other optical instrument through which light enters. The diameter of the exposed portion of the objeet-glass; as, "6-inch aperture."

Aph'lo-gis'tic Lamp. Literally, *flameless.* A lamp in which the wick, of platinum wire, is kept constantly red-hot by the slow combustion of alcohol, heated by the wire itself.

A'pi-a-ry. A place where bees are kept. It generally assumes the form of a house forming a common shelter for the hives, but in some cases the hives are more closely associated and form a cluster of families, occupying a bee "palace." This is frequently an ornamental structure with a number of apartments for brood comb, and outlying, removable boxes for containing surplus honey. The interior has provision for ventilation by gauze-lined tubes, and the portions communicate by ducts, or by holes in the partitions. Provision is made for parting off certain portions which are removable with their tenants and provisions to form a nucleus for another cluster of families. The intention of the bee-palace arrangement has been to give the bees the advantage of combined effort and at the same time prevent natural swarming by making colonies removable. Experience indicates that they run well for a season and then dwindle, becoming a prey to their natural enemies, among which the most fatal is the bee moth. Individual families are comparatively short-lived, and modern apiarists have obtained such a command over the fraternity, that the families may be divided at pleasure, with a frequency and success dependent upon the resources of the bees for food and the salubrity of the season, always bearing in mind the tribal economy of the bees, which requires the presence of a queen.

In some parts of the world the apiary consists of a collection which are formed into a village with avenues. They are sheltered in winter-quarters, and on the approach of spring are carried out to favorable localities, where they work during the honey-making season. This is especially the case on some parts of the continent of Europe, where bee-keeping is systematized and followed as a regular branch of industry, the aim being to glean the favorable territory of all the bee-supporting nutriment.

Fig. 274.



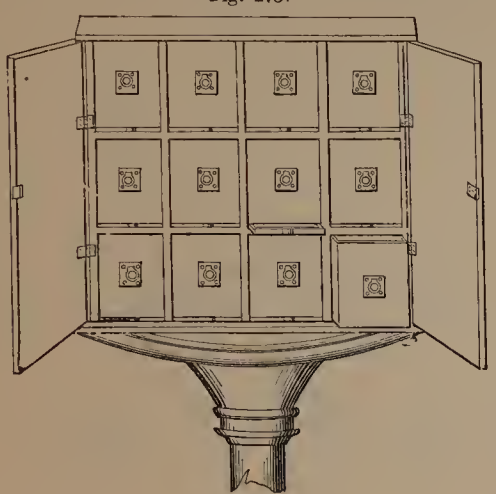
Apiary

The devices in apiaries, not considering those belonging to hives, which are considered separately (see BEEHIVE), are for ventilation, protection against storms and depredators, and for housing during winter.

In the compound hive (Fig. 274) the apartments are associated side by side in an outer case, and communicate with each other laterally, and each with its removable honey-box above. This is an illustration of the lateral arrangement; others are associated vertically.

In Fig. 275 is shown another form of apiary whose "pigeon-holes" are occupied by drawers which are interchangeable and made to commu-

Fig. 275.

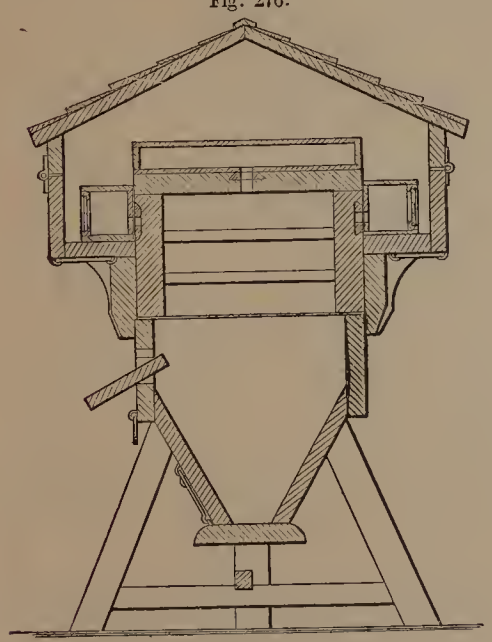


Apiary.

nicate as required. Doors inclose the front, and the whole is mounted on a pillar to raise it out of the way of mice, etc. Ventilating arrangements are made in the interior, the ramifications extending to the pockets which contain the drawrs forming the apartments. An ornamental character is given to the whole to make it an agreeable object in a bower or on a grass plat.

Another bee-palace has a frame on which the

Fig. 276.

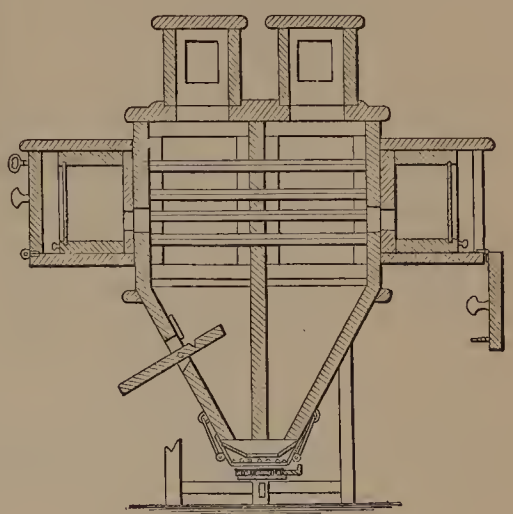


Bee-Palace.

hives are supported, shelves for honey-boxes, doors for examination or change, and an enclosing shed above for protection from heat and wet. The lower part of the case has inclined sides and a falling door at bottom for the discharge of offal.

In Fig. 277 the moths and grubs falling from the hives are directed, by the inclined sides of the lower portion, into the trap beneath. The trap has a

Fig. 277.

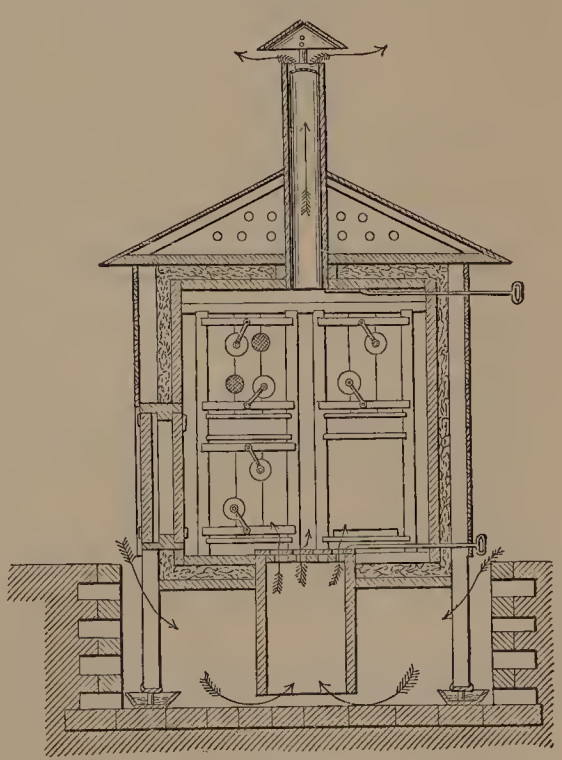


Bee-Palace.

funnel-shaped conductor, a perforated diaphragm, and a detachable bottom by which the insects and offal are removed. Additional apartments for the extension of room are added above and on the sides, and admittance to them is afforded as required by withdrawing the slides which command the ducts of communication.

Fig. 278 shows a hive which has a sunken hatch-

Fig. 278.



Apiary.

way in the center, extending into a pit so as to bring the floor of the hive about on a level with the surface of the ground. The walls and ceiling are double, and have a layer of non-conducting material. A central chimney removes the vitiated air, and registers determine the admission of air to each hive in the group. It is supported by posts which rest in cups of water to prevent access of ants and mice. The devices have particular reference to means for maintaining an even temperature; the double sides and non-conducting material obstructing the passage of heat outward in winter, and also moderating the effect upon the bees of the summer heat striking upon the sides of the hive. The equality of the temperature is also conserved by the nearness of the ground, while provision is made for removing effluvia or corrupt air which might accumulate in the pit.

Ap'la-nat'ic Lens. A lens constructed of different media so as to correct the unequal refrangibility of the different rays.

The object to be attained is that rays parallel to the axis of the lens or diverging from a point on its axis, after passing through it and suffering refraction at its surface, shall converge to a single point, the true focus. See ACHROMATIC LENS.

A-pol-lon'i-con. A large chamber-organ played by key-boards or by barrels, and exhibited in London some years since. It was constructed by Flight and Robinson in 1817. It had 1,900 pipes, 45 stops, 5 key-boards and 2 barrels. The number of keys acted upon by the cylinders was 250.

Ap'o-me-com'e-ter. An instrument for measuring hights, invented by a Mr. R. Millar, and manufactured in London.

The apomecometer is constructed in accordance with the principles which govern the sextant, viz.: As the angles of incidence and reflection are always equal, the rays of an object being thrown on the plane of one mirror are from that reflected to the plane of another mirror, thereby making both extremes of the vertical hight coincide exactly at the same point on the horizon glass, so that by measuring the base-line we obtain a result equal to the altitude.

The eye of the observer when in position will be at the lower end of the hypotenuse, and the summit of the object at the other. Keeping the line of vision, which forms the base, exactly horizontal, the observer approaches the object till the images coincide, when the base will agree in length with the perpendicular, and the measured length of the former will give the hight of the latter.

A-poph'y-ges. A molding of a rounded concave form. See MOLDING.

A-pos'tle. (*Nautical.*) A knight-head or bollard-timber where hawsers and heavy ropes are belayed.

A-pos'tro-phe. An elevated comma-shaped point (’), to indicate an abbreviation, as "don't" for "do not"; to mark the plural of figures or letters used as words, as "two 20's," "the font lacks A's"; or to mark the possessive, as "Iago's trick."

Ap'pa-ra'tus. 1. A set of tools or implements for a given duty, experimental or operative.

2. A complex instrument or appliance, mechanical or chemical, for a specific action or operation.

3. (*Nautical.*) A ship's war equipage and ammunition.

Ap-par'el. 1. Body clothing.

2. (*Nautical.*) The masts, rigging, sails, and other gear of a vessel.

Ap-pend'a-ges. (*Shipbuilding.*) Relatively small portions of a vessel projecting beyond the general shape, as shown by the cross-sections and water-sections. These parts usually consist of, —

The keel below its rabbet.

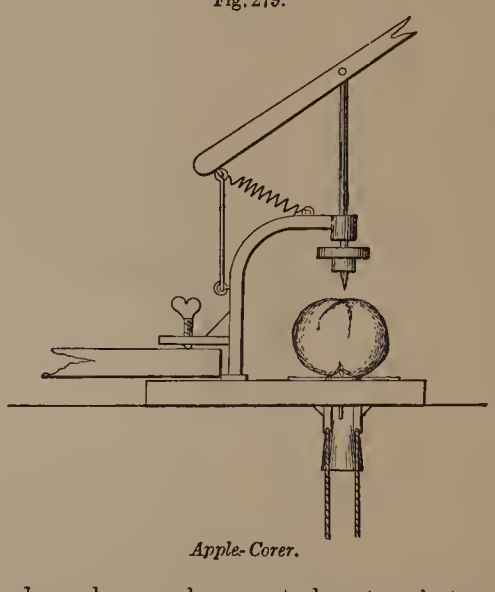
Part of the stem and stern-post.

The rudder, rudder-post, and screw (if any).

These volumes are calculated separately and added to the main part of the displacement.

Ap'ple-cor'er. Many of the apple-parers have attachments for dividing the fruit into quarters, or still more minutely; in some cases the apple is pushed from its impaling fork against a cutting-tube with radial knives, the tube receiving the core and the knives making the division. A device for coring, slicing, and stringing fruit is shown in Fig. 279. The fruit is placed above the coring-tube and its radial knives, and is pressed down upon the

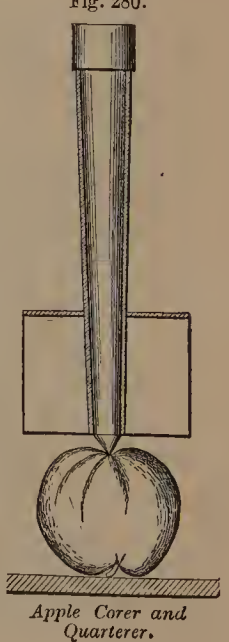
Fig. 279.



Apple-Corer.

same by a plunger whose central part projects sufficiently to drive the core into the tube. The quarters are pressed upon sharp plates which enter the fruit a short distance, and are the means of introducing strings which depend from the said plates; the successive pieces push their predecessors off the plates, and the pieces are thus strung and suspended until a sufficient quantity is gathered. The strings are then removed and empty ones attached.

Fig. 280.



Apple Corer and Quarterer.

Fig. 280 is an example of an implement consisting of a tube or circular cutter of sheet metal, slightly tapering from the cutting edge, and with four or more radial cutters projecting from its circumference. The central plunger serves as a guide in applying the implement, and is afterwards the means of ejecting the core.

Ap'ple-par'er. This is an ingenious American device, and created mingled emotions of admiration and amused surprise when it was introduced into England; the date is not remembered, but it was referred to as a novelty about 1840. There are now over eighty patents, which appear to

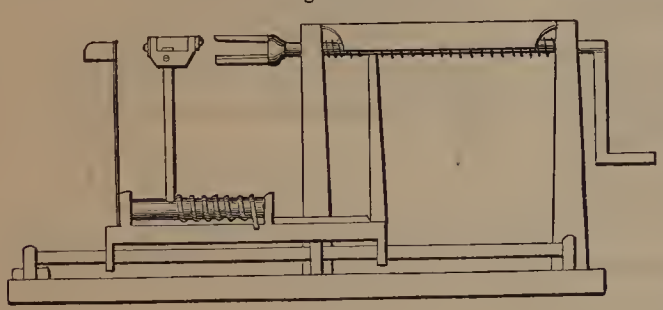
agree in one respect, that is, the rotation of the fruit on the end of a fork. The operation requires two motions, which vary in the different machines.

1. The cutter describes a semicircle in the plane of the axis of the fork while the fruit is rotating, so that it may remove a paring from the stem to the blossom end, following the rotundity of the fruit.

2. An oscillatory motion is given to the fork, whose stock describes an arc in the plane of its length, presenting the rounded surface of the rotating apple to the knife, which cuts a continuous paring from the fruit, from the stem to the blossom end.

The first patents recorded are those of COATES, 1803, and CRUTTENDEN, 1809; GATES added the quartering in 1810. The Patent-Office records perished in the fire of 1836. We find that in MITCHEL'S patent, April 13, 1838, the first granted after the fire, that the knife was operated by hand while the fruit was impaled upon a fork which was rotated by gearing. The pared apple was then pushed through an opening with a cruciform knife arrangement, by which it was quartered.

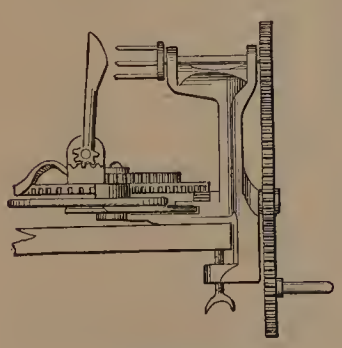
Fig. 281.



Apple-Parer.

In Fig. 281, date of 1857, the threaded shaft draws the slide, bringing the paring-knife against the surface of the apple which is impaled on the fork. The knife-stock is so pivoted on its shaft as to present the blade to the apple while following its convexity to some extent. The work is not so thoroughly done on the ends as by later inventions in which a positive semicircular sweep is given to the fruit or knife. The slicing-knife, which follows the parer, cuts the apple into a spiral, leaving a cylindrical core-piece attached to the fork. In a later machine, cams on the main and an intermediate wheel combine to oscillate a rack, which sweeps the paring-knife alternately from the stem to the calyx of one apple, and in a contrary direction on the next. The device is attached by a clamp to the table.

Fig. 282.

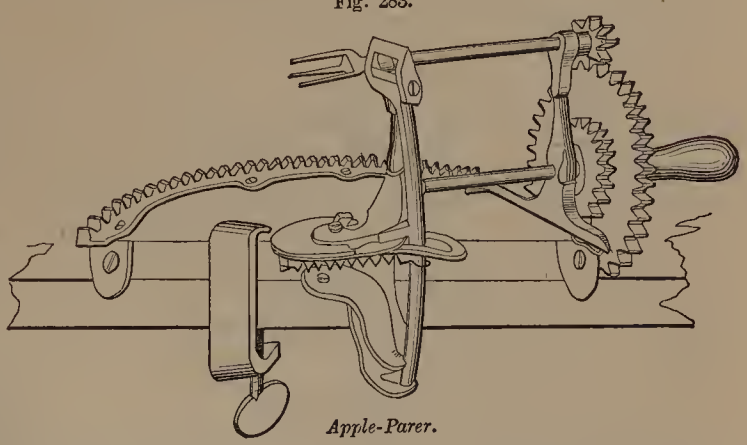


Apple-Parer.

In Fig. 282, the apple is impaled on the revolving fork, and the knife is made to sweep around automatically, as its platform is revolved by gear connection with the hand-crank shaft. The knife returns automatically to the place of commencement after making its effective sweep.

In Fig. 283 the rotation of the fork is obtained by one motion of the hand in an arc of a circle, the smaller cog-wheel on the main shaft gearing into

Fig. 283.



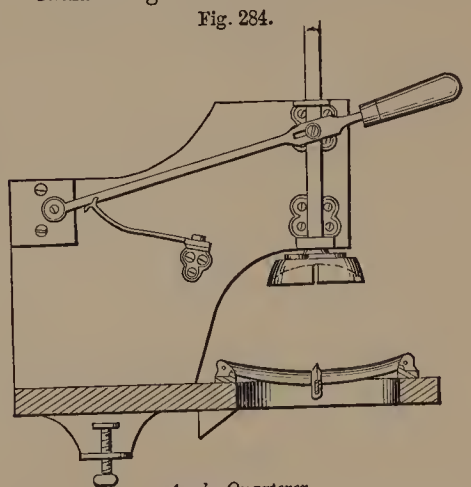
Apple-Parer.

the curved rack and moving the larger cog-wheel which runs the pinion on the fork-shaft. The paring-knife and its stock have no motion on each other, but have such a progressive and rotary movement, that, as the apple is revolved, the knife will pass from the stem to the blossom end of the apple, and adapt itself to the varying form and inequalities of the fruit being pared. The knife is automatically moved away from the fruit after the effective sweep, and resumes its operative position when returned to the starting-point.

Ap'ple-quar'ter-er. An implement for dividing apples into quarters.

A wooden plunger is pressed down upon the apple placed on a central point, and forces it between the four knives. In another form it is a coring-tube with four radial wings.

Fig. 284.



Apple-Quarterer.

Ap'pli-ca-tor. A surgical instrument, of form and proportions adapted to its specific uses, for applying caustic, a tent, or other application to a deep-seated part.

Ap-point'ments. 1. (*Personal.*) Accouterments other than arms and ammunition.

2. (*Naval.*) The furnishing or equipment of a ship.

Ap-proach'. In a military sense, either a route by which a fort, fortified town, or other military position, may be approached for the purpose of attack; or the trench or protected road constructed by the besiegers for conveying ordnance, ammunition, and stores, or for marching bodies of men to or from the parallels; in the latter case approaches may be either excavations, with the earth therefrom thrown up as an embankment on the side exposed to the enemy's shot, or they may be formed of sand-bags, gabions, fascines, or anything, in short, which will stop a cannon-ball. The works of this kind constructed during the siege of Sebastopol in 1854 and 1855 are probably without a parallel in modern history, if indeed they were ever equalled in the history of sieges. They embraced seventy miles of sunken trenches, and no less than sixty thousand fascines, eighty thousand gabions, and one million sand-bags were employed to protect the men working in the trenches and at the different batteries.

A'pron. 1. A board or leather which conducts material over an opening; as, the grain in a separator, the ore in a *buddle* or *frame*, etc.

2. The sill of a window or a dock entrance.

3. The floor of a *tail-bay*. See CANAL LOCK.

4. A leaden plate over the vent of a gun.

5. A leathern covering for the legs of the person occupying the driving-seat of a vehicle.

6. The piece that holds the cutting tool of a planer.

7. (*Plumbing.*) A strip of lead which leads the drip of a wall into a gutter; a *flashing*. See GUTTER.

8. (*Shipbuilding.*) A timber within the stem of a vessel in prolongation of the *dead* wood. It strengthens the stem, and affords wood for the reception of the plank of the bottom and the heels of the foremost timbers. See STEM.

A'pron-piece. (*Carpentry.*) A horizontal piece supporting the upper ends of the *carriage-pieces* or *rough-strings* of a wooden staircase.

A *pitching-piece*. The *carriage* which supports the steps is *pitched* or slanted against it.

Apse, Ap'sis. (*Architecture.*) *a*. The arched roof of a house, room, or oven.

b. The domed semicircular or polygonal termination of the choir or aisles of a church, where the altar was placed and where the clergy sat, in Gothic constructions.

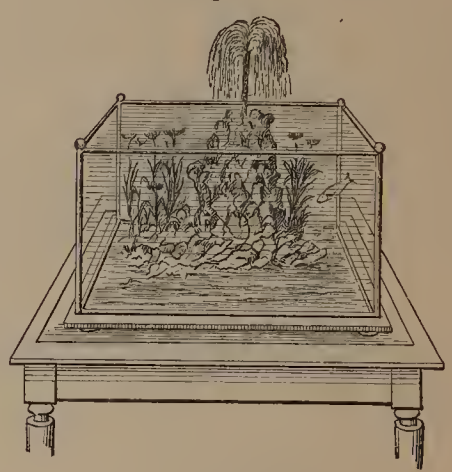
A-qua'ri-um. A vessel containing salt or fresh water in which living specimens of aquatic animals and plants are maintained; sometimes called *vivarium* or *aqua vivarium*. From the earliest times animals living in water have been kept alive in small vessels for exhibition or transportation by frequently changing the water, yet it is only since the rise of modern chemistry and physiology that the true principles of the aquarium have been discovered.

As the air contained in the water is breathed by the animals and loses its vitality, the resulting gaseous product becomes deleterious and must be removed: this is the office of the plants in the modern aquarium; these restore the oxygen and abstract the excess of carbonic-acid gas, their function in the subaqueous vegetation being similar to that performed by the ordinary terrestrial flora.

But, besides the animals and plants properly proportioned to each other to maintain the uniform composition of the air in the water, it has been found necessary to add certain animals which feed on decomposing vegetable matter and act as the scavengers in this community; such are the various species of molluscous animals, as the snails, etc. It is of importance to guard against the preponderance of animal life, for an excess of animals over plants in a given space will disturb the balance and lead to their destruction. The demonstration of these conditions is due to R. Warrington, 1850. In some cases where the supply is continuous, the fresh water maintains a healthy condition; and the same effect has been attained by a succession of bubbles of air introduced into and ascending through the water to maintain the natural equilibrium destroyed by the animals breathing therein. Agitation of the water produces the same results more or less perfectly, but the effect is not so pleasing unless it be introduced with scenic devices or machines, such as paddles, wheels, mills, or moving automatons which require a supply of water to make them constant.

In 1849 N. B. Ward grew sea-weed in artificial sea-water. A great aquarium, one hundred and fifty

Fig. 285.

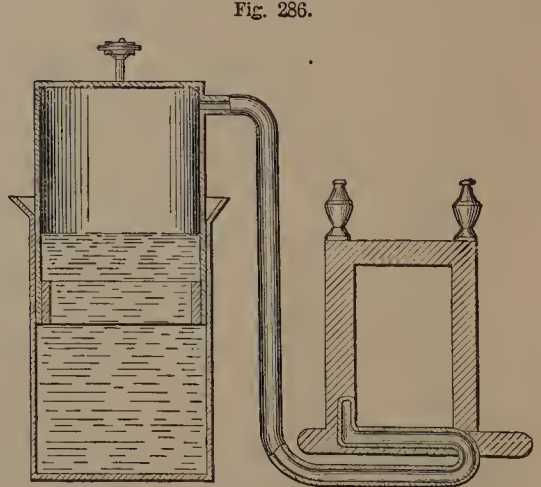


Aquarium.

feet long and thirty-six feet wide, was constructed in 1860 in the Jardin d'Acclimation in Paris by Alford Lloyd of London. The same gentleman erected a magnificent aquarium in Hamburg.

Fig. 286 shows an arrangement for the introduction of air for the revivification of the water. It is an air-forcing apparatus consisting of an inverted weighted vessel whose edges are submerged in the

Fig. 286.



Cutting's Aquarium.

water of the reservoir, and which connects by a flexible pipe with the interior of the tank. As the inverted weighted air-holder descends gradually, it

forces air through the flexible pipe into the aquarium.

The aquarium of the Paris Exposition was a remarkable success, and has given rise to much more ambitious structures. The aquarium of Brighton, England, for instance, occupies ground 715 feet in length, with an average width of a hundred feet. The aquarium proper is divided into three corridors. The first is divided again into nineteen bays, which are roofed over with bricks, groined vaulting of red and black alternating with red and buff. The arches, ribs, and bosses are of Bath stone. The extreme length of the corridor is broken most effectively by a central square 55 by 45 feet, the groined vaulting forming a sort of cloister around the square, while the central portion is covered with an elaborate ornamental iron roof, partly glazed with antique colored glass. The tanks are arranged on either side, twenty-eight in number, averaging in size from 11 × 20 feet to 55 × 30 feet. The whole front work of the tanks is of Portland stone, ornamented with appropriate devices of fish, shells, marine monsters, and aquatic symbols. These fronts are inclosed by plate glass of great thickness, secured to the stonework by waterproof cement. The area of water surface visible in the rear of the glass is 9 feet wide by 5 feet deep. The light of the corridors is only transmitted through the water, thus affording to the visitor the sensation of being under water without the inconvenience of a wetting. At the eastern extremity of this corridor, which is 220 feet in length, the visitor finds before him the entrance to a fine conservatory. This entrance is at the junction of the first and second corridors; the latter, running north and south, forms right angles with the first corridor. The conservatory is 160 feet long by 40 feet wide and 30 feet high. The ornamentation of this apartment is in keeping with that of the other parts of the building. It is chiefly intended for a sort of subterranean promenade, and is ornamented with plants, ferns, small aquaria, etc. Corridor No. 3, which is approached from No. 2, is of the same length as the conservatory, contains twenty tanks, some for fresh-water, others for salt-water fishes. At the end of this corridor are the engines and the store tanks, boiler, retiring and naturalists' rooms, and another flight of steps leading to the terrace.

The water for the tanks is supplied, by means of pumps, from reservoirs beneath the floor of the building; and by an arrangement of pipes and pumping the water is kept constantly in motion throughout the aquarium.

The whole cost about $ 250,000.

A-quat'ic Box. An accessory to the microscope in the form of a shallow glass cell in which algæ or animalculæ are placed for observation.

A'qua-tint. A peculiar style of engraving on metal said to have been invented by St. Non, a French artist, about 1662. Otherwise stated to have been invented by Le Prince, Metz, 1723. The process, briefly described, is as follows: A surface of resin is spread upon a polished plate in such a manner as to leave innumerable little interstices between the resinous particles. This surface covering is called a *ground*, and may be made in two ways, — the dry process and the solution process.

The dry process is performed by dusting over the very slightly greased surface of the plate a shower of finely powdered resin. The surplus having been removed by tapping the plate, which is held in a reversed position, the particles are caused to adhere to the plate by warming the latter over a lamp, or, what is much better, the moderate diffused heat of a piece of burning paper. In the interstices between the particles of resin the plate is exposed to the action of acid, of which presently.

The solution process consists in dissolving the resin in alcohol and flooding the plate with it, allowing the liquid to run off; a film adheres to the plate and cracks in drying, leaving innumerable fine fissures where the plate is exposed.

The design is now placed on the "ground," or it may have been previously etched in; the latter is now preferred. A wall of wax being erected around the design, it is flooded with dilute acid, as explained under ETCHING (which see). For copper plate, dilute nitrous acid is used (acid, 1; water, 5). For steel, dilute nitric and pyroligneous acid is used (nitric acid, 1; pyroligneous acid, 1; water, 6). As soon as the lighter tints are sufficiently *bit in*, the acid is removed and the plate washed and dried. The light portions being *stopped out*, that is, covered with Brunswick black to protect them from farther action of the acid, the latter is again applied for the second tint, and so on. The delicate gradations are obtained by *flooding* and *feathering*, which are nice technical operations, requiring skill only attained by practice, and for a description of which we cannot spare room. This is a cheap and effective mode of engraving, and is not estimated at its proper value. The effect produced is like a drawing in india ink.

For different grounds the resin is more or less diluted; the greater the dilution the finer the ground, that is, the more delicate and numerous are the interstices in which the acid acts. A different ground is also obtained by a change of ingredients. Bergundy pitch, mastic, frankincense, and other resins, give various patterns of grounds, so to speak.

Aq'ue-duct. A conduit for the conveyance of water. More particularly applied to those of considerable magnitude intended to supply cities and towns with water derived from a distance for domestic purposes, or for conveying the water of canals across rivers or valleys. Pocock describes one erected by Solomon for conveying water from the vicinity of Bethlehem to Jerusalem. This was formed by earthen pipes about ten inches in diameter, encased with stone and sunk into the ground, and would seem to have conformed to its inequalities, indicating a more advanced state of hydraulic engineering in Solomon's time than is commonly supposed to have been possessed by the earlier Romans, who were justly famed for their works of this kind, which have never been surpassed in strength and beauty.

The earliest account of any aqueduct for conveying water is probably that which is given by Herodotus (who was born 484 B. C.). He describes the mode in which an ancient aqueduct was made by Eupalinus, an architect of Megara, to supply the city of Samos with water. In the course of the aqueduct a tunnel, nearly a mile in length, was pierced through a hill, and a channel three feet wide made to convey the water.

The first of the Roman aqueducts (Aqua Appia) was built, according to Diodorus, by Appius Claudius, in the year of the city 441, or 312 B. C. The water which it supplied was collected from the neighborhood of Frascati, eleven miles from Rome, and its summit was about one hundred feet above the level of the city.

The second (Anio Vetus) was begun forty years after the last-named, by M. Curius Dentatus, and finished by Fulvius Flaccus: it was supplied from the country beyond Tivoli, forty-three miles distant. Near Vicovaro it is cut through a rock upwards of a

mile in length, in which part it is five feet high and four feet wide. The water of this aqueduct was not good, and therefore only used for the most ordinary purposes.

The third (Aqua Martia) was supplied from a fountain at the extremity of the mountains of the Peligni. The water entered the city by the Esquiline Gate. This aqueduct was the work of Quintus Martius, and had nearly seven thousand arches in a course of thirty-nine miles.

The fourth (Aqua Tepula) was supplied from the vicinity of Frascati.

The fifth (Aqua Julia) was about six miles long, and entered the city near the Porta Esquilina.

The sixth (Aqua Virginis) was constructed by Agrippa thirteen years after the Julia. Its summit, in the territory of Tusculum, was about eight miles from Rome, which it entered by the Pincian Gate. This water still bears its ancient appellation, being called Acqua Vergine.

The seventh (Aqua Alsietina, called also Augusta, from the use to which Augustus intended to apply it for supplying his Naumachia) was brought from the lake whose name it bears.

The eighth (Aqua Claudia), begun by Caligula and completed by Claudius, is about forty miles in length. It enters the city at the Porta Nevia, near the Esquiline Mount. The quality of the water which this aqueduct supplies is better than that of any of the others. It was built of hewn stone and supported on arcades during seven miles of its length. After a lapse of eighteen hundred years it still continues to furnish Modern Rome with pure and wholesome water.

The ninth (Anio Novus, to distinguish it from the second-named water) was begun and finished by the same persons as the last-mentioned. It is the water of the Anio, which, being exceedingly thick and muddy after the rains, is conveyed into a large reservoir at some little distance from Rome, to allow the mud to subside.

The Acqua Felice is modern, and was erected by Sixtus V. in 1581.

The Popes have, from time to time, been at considerable pains and expense in repairing and renewing the aqueducts; but the quantity of water delivered is constantly diminishing. In the ancient city the sum-total of the areas of the different pipes (which were about an inch in diameter) through which the above immense quantity of water was delivered, amounted to about 14,900 superficial inches; but the supply was subsequently reduced to 1170.

The waters were collected in reservoirs called *castella*, and thence were conveyed through the city in leaden pipes. The keepers of the reservoirs were called *castellani*. Agrippa alone built thirty of these reservoirs during his ædileship. There are five modern ones now standing in the city: one at the Porta Maggiore, Castello dell' Acqua Giulia, dell' Acqua Felice, dell' Acqua Paolina, and that called the Fountain of Trevi.

The aim of the Roman aqueduct-builders was to conduct the water along with an equal fall during the whole distance from its source to the point of delivery; and for this purpose, instead of allowing the conduits to follow the natural slope of the ground, they almost always erected long and massive stone arcades wherever it was necessary to cross a valley, instead of availing themselves of the well-known property of water to find its level. This was perhaps necessary in the then state of the mechanic arts, the art of casting iron pipes of large size being unknown.

It has been calculated that the nine earlier aqueducts of Rome had a total length of more than 249 miles, and the supply of water to Ancient Rome was computed by Professor Leslie, on the authority of Sextus Julius Frontinus, who was inspector of the aqueducts under the Emperor Nerva, and who has left a valuable treatise on the subject, at fifty million cubic feet per day for a population of one million souls. This gives the immense average per head of fifty cubic feet, or three hundred and twelve gallons, per diem, — a consumption quite unequalled in modern times, except in the city of New York, where it is said to have formerly amounted nearly to this quantity.

The aqueducts of Metz, Nismes, and Segovia are also striking examples of the attention paid by the Romans to the subject of supplying water to their towns and cities.

It does not appear that the ancients were by any means ignorant of the applicability of pipes for conducting water, and it is difficult to conceive how it could have been distributed to the baths and fountains of Rome without their aid. Their system appears to have been the result of calculation and design, and it is notable that in the greatest works of the kind of modern times, such as the aqueduct of Marseilles and the Croton Aqueduct, their leading principles have been carried out, and the use of pipes following the elevations and depressions of the hills and valleys has been in a great degree dispensed with, where the water had to be conveyed along a course of considerable length, — though, in general, without resorting to such an extensive, or indeed excessive, use of long and expensive arcades as the Romans employed.

The advantages of this system seem to be, more perfect freedom from deposition of mineral substances in solution in the channel way, owing to the more uniform and regular flow of water which can be obtained; facility of constructing traps or wells along the route for the deposition of sediment; greater security from interruption and opportunity for repair in case of accident.

The aqueduct of Nismes, or the Pont du Gard, in France, is one of the earliest constructed by the Romans out of Italy, and is supposed to have been built in the time of Augustus; it was intended for carrying the waters of the Eure and Airan from the vicinity of their sources to the town of Nismes.

The commencement of this aqueduct was conducted along the sinuosities of a hill, entirely under ground, and was often cut in the rock itself. Small bridges were thrown over the streams crossed in its course, and it passed over a series of arches, resembling those of the upper part of the great arcade of the Pont du Gard, followed the crest of a hill to avoid unnecessary hight in the piers, and after a course of about 9⅘ miles arrived at the Pont du Gard, by which it is carried over the river Gardon at a hight of more than 157 feet above the surface of the stream below.

This magnificent structure consists of three tiers of arches, on the upper one of which the water-way is carried. The length at the level of the string course surmounting the lower tier of arches is 562 feet, and at the string course of the second tier 885 feet.

The large arch through which the river passes is 80 feet 5 inches in span, the three on the right side of this are 63 feet, and the smaller ones 51 feet. Those of the upper story are all equal, 15 feet 9 inches in span; their piers vary in width, and do not come immediately over those below.

The whole is constructed of freestone, from the foundation to the third course above the cymatium

covering the piers of the upper story. Rubble was employed for filling in the piers, spandrels, and haunches of the first and second stories.

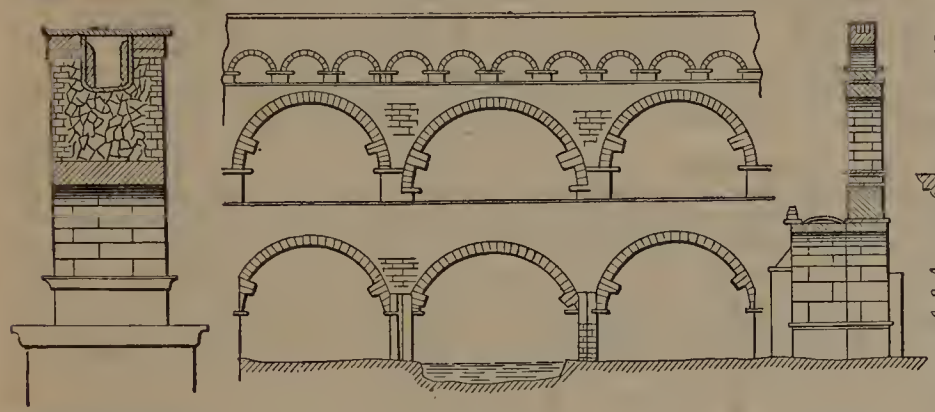
The stones were laid without cement, each being raised by the lewis, the holes for the insertion of which are still to be seen exactly over the center of gravity of each stone.

The dimensions of the water-way are 4 feet in width and 4 feet 9 inches high; the fall throughout its entire length is 2.112 inches per mile, and it is estimated to have been capable of supplying from 14 to 18 millions of gallons of water per day.

The entire length of the aqueduct is over 25½ miles.

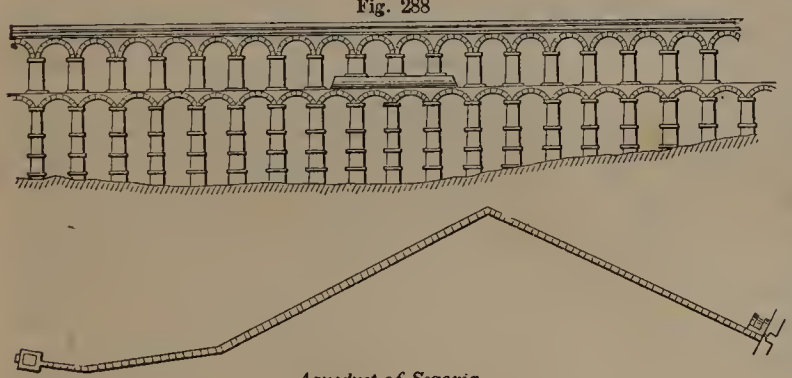
The aqueduct of Segovia, Spain, was built by the Emperor Trajan, and is of squared stone laid without mortar, and in crossing a valley has a length of more than 2,200 feet; it is in many places nearly 100 feet high. An elevation and plan are shown in Fig. 288.

Fig. 287.



Section of Upper Story, enlarged scale. *Pont du Gard.* Side Elevation. Section.

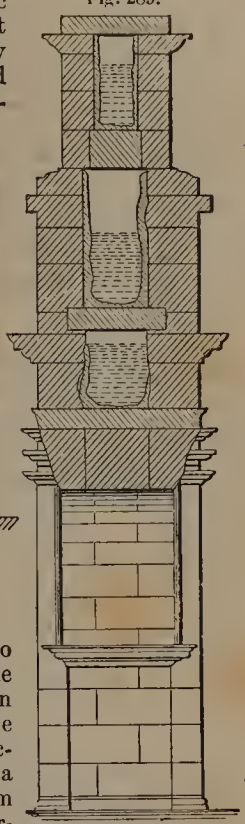
Fig. 288



Aqueduct of Segovia.

The waters of the Aquæ Julia, Tepula, and Martia at Rome were conducted through a triple aqueduct, forming three channels, one above the other, as shown in the accompanying section; the Aqua Martia being the lowest, the Aqua Tepula the middle, and the Aqua Julia the uppermost of the series. Particular care was taken to prevent leakage from one into the other, so that the water of better quality might not become deteriorated by mingling with that of inferior clearness and purity; to effect this, the bottom of the channel of each was based upon thick stones passing into the sides of the aqueduct, and carefully lined with tiles and a coating of cement. Doors from the outside admitted the persons in charge to examine the condition of the conduits at any time, and they were required to report constantly upon their efficiency and state of repair.

Fig. 289.



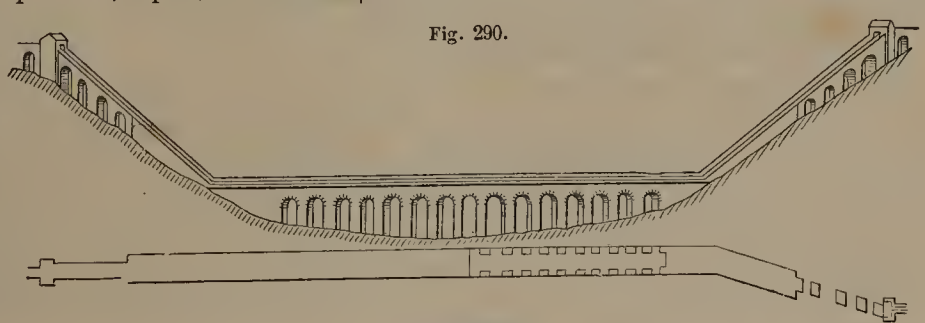
Roman Aqueducts, Julia, Tepula, and Martia.

The accompanying illustration (Fig. 290) shows one plan adopted by the Romans for conveying water across a valley. The aqueduct was erected by the Emperor Claudius for supplying a palace in an elevated part of the ancient city of Lugdunum (Lyons).

The channel-way, both in ascending and descending, was formed by masonry, tiles, and cement.

The work was performed as follows: A level pavement was formed of brick, on which was raised a frame or caisson of timber planks; against the sides of this, squared stones were laid in regular courses, and their interior filled in with rubble in a dry state, after which a grouting of liquid cement was poured in to consolidate the whole. Lime, fine

Fig. 290.



Lyons Aqueduct.

gravel or sand, mixed with a due proportion of water, formed this grouting. After a sufficient time had allowed this work to consolidate, the caisson was mounted upon another course or layer of tiles, and similar operations to the first took place.

The bricks or tiles used were 21 inches in length, 12 inches in breadth, and 1½ inches in thickness.

The whole of the water conduit was coated with cement; at bottom, its thickness was 6 inches, at the sides 1½ inches. 24 inches from the bottom of the canal, at distances of 30 inches apart, the side walls were stayed with iron ties to prevent their being burst apart.

In the ancient aqueduct at Lyons, called at one part of its course Mont de Pile and at another Champonest, the water was brought over eight bridges in the usual manner, and a siphon was employed for conducting it across the ninth. At this point the valley is very deep, and a reservoir was built from which leaden pipes of large size, bedded in the sides of the valley, conducted the water to others laid over a bridge in an inverted curve; they were then conducted up the opposite side of the valley, and delivered the water into a reservoir at the same level as the first; from this they were conducted under ground for some distance, and thence, by a bridge of ninety arcades, to another reservoir, from whence it again descended into a valley through similar leaden pipes, crossing a river and ascending the other side of the valley, where it was delivered into a reservoir on that side. From thence it was carried, partially over arcades, to a reservoir at one of the gates of the city, from whence again it was carried by leaden pipes, first falling and again rising until it reached the reservoir from whence it was finally distributed; in this last instance the pipes were bedded in solid masonry, and not carried over a bridge.

The total length of this remarkable piece of work, which certainly seems to combine all the known appliances for conveying water without the aid of extraneous mechanical power, was 13 leagues, and the fall in this distance upward of 350 feet.

Wherever the aqueduct was tunneled in the sides of the hills at a considerable distance below the surface, wells were sunk to carry off any vapors which might accumulate, and to admit light and air; they also afforded access to any workmen who might be employed to make repairs or remove accumulated deposits in the channel: these were at distances of 120 feet apart. Perpendicular vent-pipes were also erected for ventilating purposes. The walls, where the work was above ground, were two feet thick, and the arches were roofed over to shed rain. The entrance to the aqueduct was through iron doors opening internally. The underground portions were accessible by traps or man-holes brought up a little above the level of the soil.

Pipes, in cases where a very large supply of water is not required, undoubtedly possess many advantages, and in very broken and rugged localities their use, either alone, or in combination with masonry or brick conduits, along the more level portions of the route, is indispensable without increasing the cost of the work beyond all reasonable bounds; but it would seem, both from the experience of antiquity and that of more recent times, that the stone or brick channel into which the air is freely admitted, and to which ready access can be had for the removal of impurities or obstructions, is, when the engineering difficulties and cost are not too great, preferable to any other.

This of course does not apply to the delivery and discharge of water within cities or towns; there, metallic pipes of some kind are indispensable. Cast-iron is the material now universally employed for the larger pipes of this description, called *mains*, and is perfectly unobjectionable in every respect. Leaden pipe is very extensively employed in buildings for discharging water, but, unless kept constantly filled, is a very dangerous material, its salts being active poisons. Lining with tin is a good expedient.

In China and Japan, bamboos of large size are used to convey water from one point to another.

The ancient works executed under the later Roman emperors for the supply of Constantinople combine the system of aqueducts with the collection and impounding of water by means of reservoirs at the head of the aqueduct. The impounding reservoirs are situate about twelve miles from the city, on the slopes of a range of mountains which form the southeastern prolongation of the great Balkan chain. There are four principal aqueducts, one of which conveys the water collected by three separate reservoirs, while the other three are each supplied by its own reservoir. Besides these extensive provisions for securing water to the city, there are immense subterranean reservoirs, one of which, now in ruins, is called the Palace of the Thousand and One Pillars, not because this is the precise number supporting the roof, but because the number is a favorite one in the expression of Eastern hyperbole. This great subterranean cistern is supposed to have been made by the Greek emperors for the purpose of storing water in case of a siege or similar calamity. Although originally of great depth, it is now nearly filled up with earth and rubbish. It is singular that in the nineteenth century we are reviving in our covered reservoirs, for the purpose of storing water in a state of freshness and uniform temperature, the practices which were followed nearly two thousand years ago by nations whose modern descendants are half barbarians.

Works of great magnitude were, according to Garcilasso, constructed for purposes of irrigation by the ancient Peruvians, previous to the conquest of that country by the Spaniards.

On the western slopes of the Andes there are immense districts where rain never falls, and which are incapable of cultivation unless watered by artificial means. The Incas caused numerous aqueducts to be constructed for this purpose: one of these is stated to have been 120 leagues in length and 12 feet in depth, and to have watered a tract of country more than 50 miles in width; another was 150 leagues in length, traversing an extensive province and irrigating a vast and arid district of pasture land.

The Peruvians do not appear to have advanced so far as the use of bridges or pipes for conducting the water across valleys, — their purpose probably did not require it, — but gave their aqueducts a sinuous course, winding around the mountains and through the valleys with sufficient inclination to allow the water to flow freely.

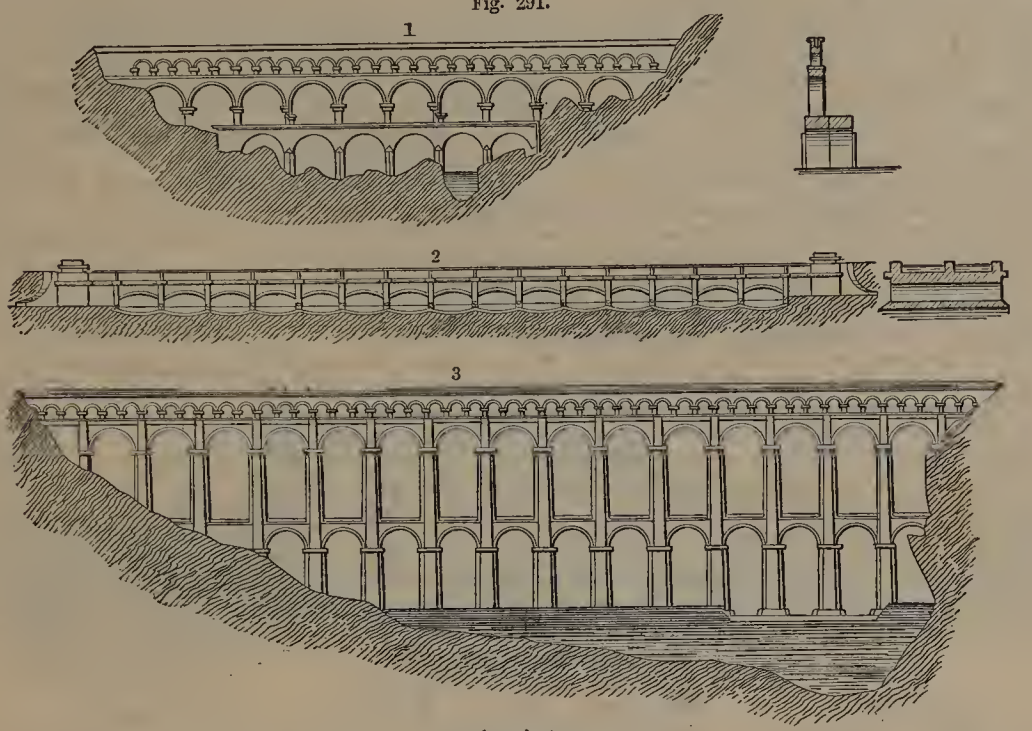
The French aqueducts referred to in this article are most of them of great magnitude and importance, and the most stupendous work of the kind ever projected originated in France. This was the aqueduct of Maintenon, which was undertaken in 1684 and abandoned in 1688, during which time 22,000,000 francs are said to have been expended upon it. It was intended to have brought water from the river Eure at Pongoin to Versailles, a distance of nearly 25 leagues, and embraced an arcade of masonry 16,090 feet in length, comprising three tiers of arches at its highest part.

The illustrations (Fig. 291) exhibit to the same scale, —

1. The *Pont du Gard Aqueduct*, at Nismes, under which the river Gardon passes, and which was built by the Romans, possibly by Agrippa. The conduit is 157 feet above the river, and is referred to above.

2. The *Solani Aqueduct* of the Ganges Canal;

Fig. 291.



Aqueducts.

the area or the water-way is eighty times that of the Pont du Gard.

3. The *Roquefavour Aqueduct*, erected by Montricher to conduct the waters of the Durance to Marseilles.

The aqueduct for supplying Marseilles with water extends from the river Durance, a distance of 51 miles, though a very hilly country. It comprises 78 tunnels, having a united length of over 12 miles. It has 500 bridges, embaukments, and other artificial constructions. Marseilles lies in a large arid basin, and the aqueduct approaches the edge of the basin at a hight of 500 feet above the level of the sea. Branches extend to and irrigate the area of 25,000 acres, and also supply the city of Marseilles. The bridge over the valley of the Are is 1,287 feet in length and 262 feet in hight. It is formed of a triple tier of arches; is said to have occupied from 700 to 800 workmen for seven years, and to have cost $750,000. The water channel is 30 feet wide at top, 10 at bottom, and is 7 feet deep. It delivers 11 tons of water per second.

The aqueduct of Chirk on the Ellesmere and Chester Canal in England is noted as being the first in which iron was employed, the bottom of the water channel being of cast-irou and the walls of masonry; that of Pont-y-Cysyllte, on the same eanal, has the entire channel made of east-iron arches or ribs resting on pillars of stone.

It carries the waters of the canal across the valley of the Dee. It is upwards of one thousand feet in length, consisting of nineteen arches of equal span, but varying in their hight above the ground. The three shown in elevation in Fig. 292 are the highest, being those which cross the river Dee itself; the surface of the eanal is one hundred and twenty-seven feet above thc usnal level of the water in the river. The aqueduct itself is a cast-iron trough formed of plates with flanges securely bolted together. This trough is supported upon cast-iron arches, each composed of four ribs, supported upon piers of masonry. The towing-path overhangs the water, being supported at intervals on timber pillars.

Watt's submerged aqueduct across the bed of the Clyde was an articulated pipe whose joints rendered it flexible, so as to accommodate itself to the shape of the river-bed. It is stated to have been a success.

Fig. 292.

Pont-y-Cysyllte Aqueduct.

The Croton Aqueduct was commenced in 1837 and completed in 1842, costing $8,575,000.

Its length is 40½ miles, 33 miles of which distance it is built of stone, brick, and cement, arched above and below. It has a capacity for discharging 60,000,000 of gallons per day. It is carried over the Harlem River by pipes laid upon a bridge consisting of fifteen arches, eight of 80 feet and seven

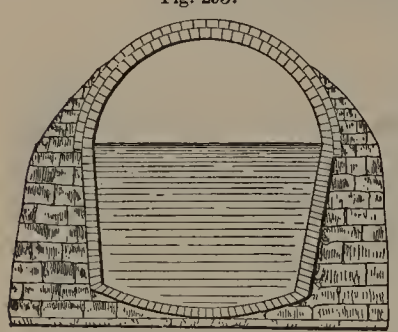
of 50 feet span, rising to 114 feet above low-water mark.

At the spot where the Croton dam is constructed, the surface-water of the creek was about 38 feet lower than the elevation required as a head for the delivery of the water into the city of New York at a sufficient hight. By going farther up stream a dam of less hight would have been sufficient, but the supply of water would of course have been smaller. The medium flow of water at the dam is about 50,000,000 gallons daily, and the minimum in very dry seasons about 27,000,000 gallons.

The water is set back upon the course of the creek by the dam, about six miles, forming the reservoir, which has an area of about 400 acres, now called Croton Lake. The available capacity of this reservoir down to the point where the water would cease to flow into the aqueduct is estimated at 600,000,000 gallons, in addition to which the receiving reservoir in the city is capable of containing 150,000,000 more when full, which together afford a reserve supply of 750,000,000 gallons in seasons of extreme drought. In case of necessity other streams might be turned into the Croton River at or above the reservoir, or into the aqueduct.

From the dam at the lower end of Croton Lake to the receiving reservoir there is no essential change made in the form of the channel-way, except that, in crossing the Harlem River and a valley on Manhattan Island, iron pipes are used instead of masonry; at these places the pipes fall and rise again so that they are always full. The channel-way of masonry is never entirely filled, so as to cause a pressure on its interior surface. To avoid this, six waste weirs were constructed at suitable places to allow the water to flow off upon attaining a certain level.

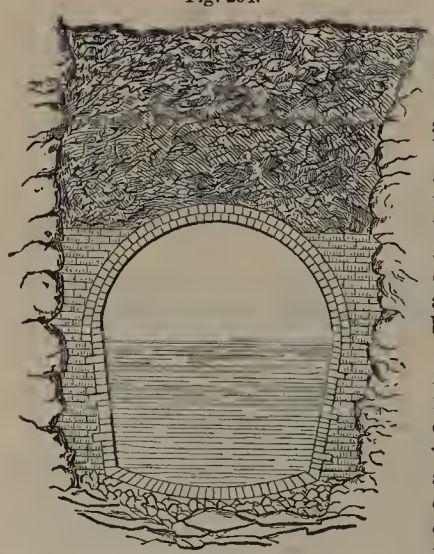
Fig. 293.



Earth Excavation.

Fig. 293 is a section showing the kind of masonry used in earth excavations.

Fig. 294.



Rock Excavation.

The foundation is of concrete, the side walls of stone, the bottom and sides of the interior faced with brick, and the top covered with an arch of brick.

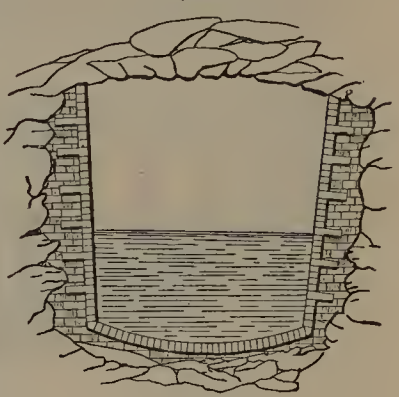
After the masonry was finished the excavation was filled up around it and over the top of the covering arch, generally to the depth of three or four feet, and in deep excavations up to the natural surface.

Fig. 294 shows a section in open cuttings in rock. The rock was excavated to the requisite depth and width, and the bottom filled in with concrete to the proper hight and form for receiving an inverted arch of brick; the side walls were of brick bonded with an outer casing of stone, built up closely against the sides of the rock. On the exterior of the roofing arch, and filling the space between it and the rock, spandrels of stone were built.

When finished, the space above the masonry was filled in with earth.

Fig. 295 is a section in tunnel cuttings in solid rock. In hard, sound rock the natural rock often served as a roof, but when soft, a brick arch was built over the channel walls and the space between its upper surface and the rock filled in with well-rammed earth. In some cases where the rock was originally hard, it was found to become soft and insecure upon exposure to the air, rendering it necessary to arch over the channel-way to support the natural roof.

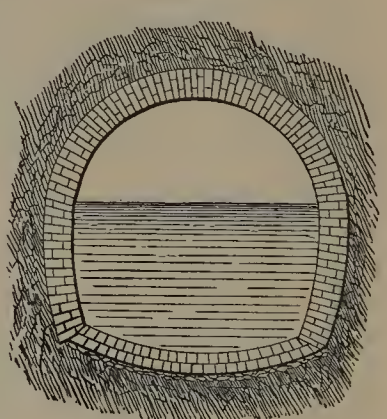
Fig. 295.



Rock Tunnel.

Fig. 296 is a section in earth tunnel cuttings. In dry and compact earth the excavation for the bottom and sides was made of just sufficient size to receive the masonry built closely against it; the top was made high enough to give room for turning the roofing arch, and when complete the space above it was filled with earth closely rammed. In wet earth the excavation was made larger and the top and sides supported by props of timber and plank until the masonry was completed; the vacant space around it was then compactly filled with earth. In crossing valleys, the aqueduct was supported on a foundation wall of stone, laid dry, and sloping embankments of earth were thrown up on each side of it.

Fig. 296.



Earth Tunnel.

At intervals of a mile apart, ventilating shafts of stone were erected over the aqueduct, rising about 14 feet above the surface of the ground; every third shaft was provided with a door to afford entrance to the interior of the aqueduct for the purpose of inspection or repairs. Openings two feet square were also made in the top of the roofing arch every quarter of a mile; each of these was covered

by a flag-stone, and its position indicated by a small monument projecting above the surface; these are for the purpose of obtaining entrance or increasing the ventilation if necessary. Where the line of the work was intersected by streams, culverts were built to allow the water to pass under without injury to the aqueduct.

In connection with the reservoir at the dam is a tunnel and gate-chamber. The gate-chamber is not directly connected to the dam itself, but is at a distance of upwards of 200 feet. The water is conducted from the reservoir to the gate-chamber by means of the tunnel T, which is cut through the solid rock of the hill, having its entrance above the dam, its center being about 12 feet below the surface of the water, so that the entrance of floating bodies is prevented. In winter, when the reservoir is frozen over, there is no obstruction to the flow of water into the aqueduct, and in summer the water is drawn from a level where it is cooler and purer than at the surface.

The gate-chamber has two sets of gates, the one being called regulating gates, R, and the other guard-gates, G, G. The regulating gates are made of gun-metal, and work in frames of the same material, fitted to stone jambs and lintels; the guard-gates are of cast-iron, working in cast-iron frames, also attached to stone jambs and lintels.

The gates are managed by means of wrought-iron rods, having a screw on their upper part working in a brass nut set in a east-iron socket-cap.

The accompanying view (Fig. 297) exhibits a section of the hill through which the tunnel is cut, showing its entrance into the reservoir, the gate-house and gates, and the point of discharge into the channel-way of the aqueduct.

Fig. 297.

Dam and Gate-Chamber.

In the center of the dam and on its ridge is a gate-house over a culvert passing through the dam. This culvert is 30 feet below the surface of the water when the reservoir is full, and has gates opened by rods rising up into the gate-house. When the river is low, the water which is not carried off by the aqueduct may be allowed to pass through this culvert, preventing any from passing over the dam.

The bottom of the water-way of the aqueduct at the gate-chamber is 11.4 feet below the surface of the reservoir, and 154.77 feet above the level of mean tide at New York City.

The aqueduct is divided into different planes of descent from the gate-chamber at the dam to that of the receiving reservoir on Manhattan Island, and is as follows: —

	Length.		Descent.
	Feet.	Miles.	Feet.
First plane of aqueduct	26,099 72	4.943	2.94
Second plane of aqueduct	148,121.25	28.053	30 69
Length of pipes across the Harlem River	1,377.33	0.261	
Difference of level between the ends of the pipes			2.29
Third plane of aqueduct	10,733 14	2.033	2.25
Length of pipes across the Manhattan Valley	4,105.09	0.777	
Difference of level between the ends of the pipes			3.86
Fourth plane of aqueduct	10,680.89	2.023	1.60
	201,117.42	38.090	43.63

The hight of the interior of the aqueduct is 8 feet 5½ inches, and the greatest width 7 feet 5 inches; the interior having a sectional area of 53.34 square feet. On the first plane the aqueduct is larger, being 2.05 feet higher at the gate-chamber, 2.31 feet higher at 2,244 feet from the chamber, and diminishing to the head of the second plane, where it is of the dimensions above stated.

The curves used in changing the course of the aqueduct are generally of 500 feet radius; in some cases a radius of 1,000 feet or even more was employed.

The receiving reservoir is located between Sixth and Seventh Avenues and Seventy-ninth and Eighty-sixth Streets in the upper part of the city of New York. It is 1,826 feet long and 836 feet wide at the top of the external walls of the embankment, having a total area of 37 acres, the area of the water-surface being 31 acres. The reservoir is divided into two divisions by means of an embankment, either of which may be used independently while the water is drawn off from the other, in case of repairs, etc.

The greatest depth of water in the north division is 20 feet, in the south, 30 feet, and the total capacity of the whole 150,000,000 gallons. The aqueduct enters a gate-chamber in the south division, where there are regulating gates for discharging the water into either division by a continuation of the aqueduct within the reservoir. The two divisions are connected by a cast-iron pipe for equalizing the level of water in each. There is also a waste weir for the escape of surplus water into a sewer.

The embankment is of earth, protected on the outside by a stone wall four feet thick, the face of which is laid in mortar; the inside slope has a stone facing, 15 inches thick, laid without mortar.

From the receiving reservoir the water is carried by iron pipes to the distributing reservoir, a distance of 2.17 miles, with a fall of four feet. The distributing reservoir is 436 feet square at the base and 425 feet square at the corners, having an area of rather more than four acres, and a capacity of 20,000,000 gallons.

The outside walls have openings, so that by entering a door one may walk entirely round the reservoir within the walls, giving a greater breadth with

a given amount of material, and affording an opportunity of examining the work for the purpose of obviating leakage, and also preventing water from finding its way to the exterior and causing injury to the wall by freezing. This open space rises to within about eight feet of the water-line. Inside of the wall is an embankment of puddled earth faced with hydraulic masonry 15 inches thick.

From the distributing reservoir the water is distributed over the city by means of cast-iron pipes of from 36 to 4 inches diameter.

The total cost of the work was $8,575,000, including the purchase of land, etc., being within five per cent of the engineer's estimate. In this the cost of the distributing pipes within the city is not included.

The Washington Aqueduct was built at the expense of the United States government, for the purpose of supplying the cities of Washington and Georgetown with water, and is distinguished by some bold features of engineering. The most remarkable of these is the bridge over Cabin John Creek, near the upper termination of the work, the widest spanned stone arch at the time of its construction; it has a span of 220 feet and a rise of 57 feet 3 inches.

The bridge over Rock Creek is also a peculiar and noteworthy application of the results of modern science and mechanical skill. The water is carried across this stream (which divides the cities of Washington and Georgetown) by means of two arches of cast-iron pipes of 3 feet 6 inches interior diameter, formed of sections with flanges firmly screwed to each other and braced; upon these are laid a bridge over which the street cars pass, and which serves as a public avenue of communication between the two cities. The span is 200 feet, and the rise 20 feet.

The aqueduct which supplies Madrid with water, and has a large surplus for irrigation, is fed from the river Lozoya, where it emerges from the Guadarama Mountains. This work was constructed under the superintendence of Don Lucio del Vallé, between 1851 and 1858, and is 47 miles in length. The river gorge is crossed by a cut-stone dam, 98 feet in hight, its wings abutting upon the solid rock of the hillsides. The artificial lake thus formed contains 100,000,000 cubic feet of water. The cost of the whole work was 57,897,368 francs.

The "canal," as it is termed, has seven miles of subterranean galleries, 4,600 feet of aqueducts, and 8,600 feet of inverted siphons at the crossings of three valleys. The siphon of Bedonal is 4,600 feet in length. The transverse section of the waterway has an area of about 20 square feet, and it discharges 6,600,000 cubic feet of water per day; one fifth is required for town service, the remainder being used in irrigating a tract of nearly 5,000 acres.

The town service has 45 miles of brick culverts about six feet high, and 60 miles of cast-iron pipes. It supplies 35 public fountains, and has 3,000 plugs for fire and irrigating purposes.

A novel expedient for the support of an aqueduct across a densely wooded ravine was suggested by Mr. M'Taggart, the resident engineer for the Rideau Canal in Canada. In a part of the country traversed by the canal, materials for forming an embankment, or stone for building the piers of an aqueduct, could not be obtained but at a great expense. The plan consisted of cutting across the large trees in the line of the works, at the level of the bottom of the canal, so as to render them fit for supporting a platform on their trunks, and on this platform the trough containing the water of the canal was intended to rest.

Ar'a-besque [ar'a-besk]. 1. (*Architecture.*) A species of ornament, either painted, inlaid, or carved in low relief, employed for decorating flat surfaces. It usually consists of convoluted and intertwined curves, intended to represent foliage, tendrils, and openwork checker patterns.

In a degraded form, various figures of animals, real or imaginary, have been introduced in the attempt to make it more consonant with the later taste for florid ornament. The Koran forbids the representation of the human form, but some have even deviated so far from the original designs of the Arabs as to blend satyrs, sirens, and mermaids in the design. This is on a par with the taste which degrades consoles into caryatides and pillars into atlantes.

2. (*Bookbinding.*) The English term for the impressed ornamental work on the sides of cloth and leather-bound books.

It is produced by the pressure of hot plates or rollers having the pattern engraved on them.

Ar-bac'cio. (*Fabric.*) A coarse woolen cloth made in Sardinia from the wool of an inferior breed of sheep, called the *Nuoro*.

Ar'bal-est. A kind of cross-bow used formerly by the Italians, and introduced into England in the thirteenth century. The arrows shot from it were termed *quarrels*.

Ar'bor. (*Machinery.*) *a.* An axle or spindle of a wheel or pinion. The term is specially used in horology.

b. A mandrel on which a ring, wheel, or collar is turned in a lathe.

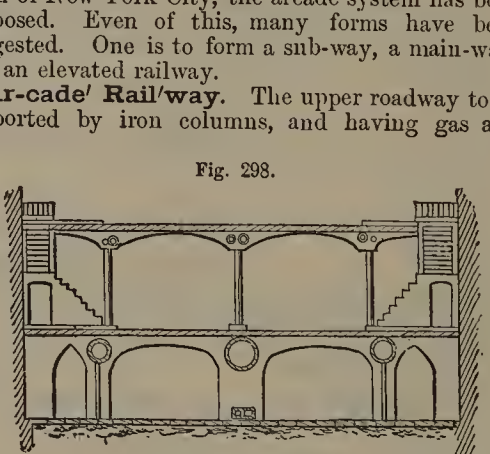
Ar-cade'. A vaulted avenue. A covered passage.

A number of streets in London and Paris are thus vaulted over, and are well known to many of our citizens; the Lowther and Burlington Arcades of the former city, for instance.

As one mode of connecting down-town and up-town of New York City, the arcade system has been proposed. Even of this, many forms have been suggested. One is to form a sub-way, a main-way, and an elevated railway.

Ar-cade' Rail'way. The upper roadway to be supported by iron columns, and having gas and

Fig. 298.



Arcade Railway.

water tubes; the main-way by masonry, through which the sewers and pneumatic dispatch pass. Access to be had to the various levels by ramps and staircases.

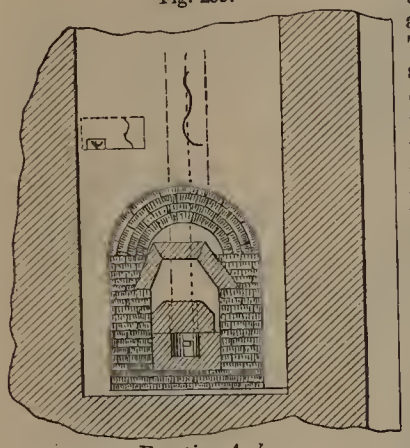
Arc'bou-tant. An arched buttress forming a lateral support for the foot or haunch of another arch.

Arch. The antiquity of the arch, says Wilkinson, is traced to the time of Amunoph I., who reigned 1540 B. C. He also thinks it probable that the chambers of the brick Pyramids at Memphis, erected by the successor of the son of Cheops, would

prove to be vaulted over with arches, which would carry back the antiquity of the arch to 2020 B. C.

In one of the Egyptian pyramids is an arch turned over three stones which formed a stone arched ceiling to the sarcophagus chamber. The two outer stones were set edgeways and inclined inward, having the other placed upon them, forming an arch.

Fig. 299.



Egyptian Arch.

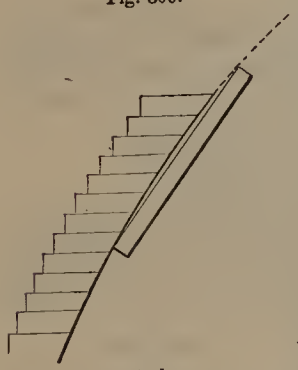
Over these stones was turned a brick arch, the radius of which was 6 feet 2 inches, and the span 11 feet. It consists of four courses, and is 3 feet 10 inches thick. The stones beneath were 4 feet long, and 15 inches in breadth. At the back the joints were packed with chips, and the whole was grouted with fluid mortar.

This tomb is of the time of Amunoph I., 1540 B. C. The stone arch at Saccara is of the time of Psammeticus II., 600 B. C. The arches of the tombs of Beni Hassan are coëval with Osirtasen II. and the Viceroy Joseph.

Arches are found in Chinese bridges of great antiquity and magnitude; and as before shown, those of Egypt far antedate the periods of Greece or Rome. Arched vaults are found among the ruins of Nineveh.

A building at Mycenæ, in Greece, called "Treasury of Atreus," has an interior pointed dome of 48 feet diameter, and of about the same hight, the section presenting two intersecting arcs of about 70 feet radius. The difficulty of working voussoirs has been evaded by making the beds horizontal throughout, the top being formed of a flat stone. The soffit of each course was then cut to the required angle with its bed by means of a templet cut to the radius of the vault (Fig. 300).

Fig. 300.



Arch.

This form of arch is sometimes known as the "Egyptian," and of course is an arch merely in name, the constructive principle being entirely different, as the stones of which it is composed are only subject to vertical pressure.

The Greeks did not allow arches to appear in their visible architecture, but used them for covering drains and the like, as in the temple of the Sun at Athens and that of Apollo at Didymos. It was, however, contrary to their architectural principles to admit any but straight lines into any visible part of a building, except, perhaps, as mere ornamentation, thus sacrificing in many instances convenience to secure that severe simplicity of outline by which their public structures were characterized. The Romans made very free use of them. The Cloaca Maxima, or Great Sewer, of Rome, is the oldest known example of Roman workmanship; it is believed to have been constructed more than five hundred years before the Christian era, and is yet in a perfect state of preservation, still continuing to perform its original functions. That people also used arches as triumphal monuments; the arch of Titus was erected A. D. 80; that of Trajan, A. D. 114; and of Constantine, A. D. 312. The Gothic style, which originated about the ninth century, and soon spread over the whole of Europe, was emphatically the style of arches. Its special characteristics are the clustered pillar and the pointed arch. The mediæval masons treated them with a boldness and freedom unknown to the builders of Ancient Rome.

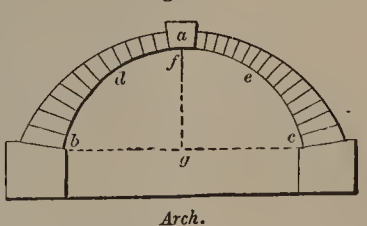
Their constructions display an astonishing amount of practical science, and clearly show that their taste was equal to their skill. Long before the properties of the catenary had been developed by Hooke, it is more than probable that they were known in practice to the old Freemasons who built Henry VII.'s chapel and other structures of similar and previous date. The span and hight of some of the principal vaulted arched structures are as follows: —

Date.		Breadth.	Hight.	Proportion.
		Feet.	Feet.	
Tarquin I.	The Cloaca Maxima	16	26	1 : 1.625
1st century	" Temple of Peace	83	121	1 : 1.46
13th "	Cathedral of Salisbury	35	84	1 : 2.3
" "	" of Amiens	42	147	1 : 3.5
" "	Westminster Abbey	33	99	1 : 3.
14th "	Milan Cathedral	55	165	1 : 3.
17th "	St. Peter's, Rome	84	147	1 : 1.75
" "	St. Paul's, London	41	82	1 : 2.

For examples of arches used in bridge construction, see BRIDGE.

The term "arch" in its widest signification, is commonly understood to mean almost anything of a curved shape employed for the purpose of bearing weight or resisting pressure, but in its more restricted mechanical sense may be defined as a collection of wedge-shaped bodies termed *voussoirs* or arch-stones, of which the first and last at each extremity are sustained by a support or abutment, while the intermediate ones are held in position by their mutual pressure and the adhesion of the mortar or cement interposed between them. The center voussoir *a*, in the highest part, or *crown*, of the arch, is called the *keystone*. The inferior surface of the arch, *b d f c c*, is the *intrados*, or *soffit*, but this latter term is sometimes restricted to that part of the under surface in the immediate vicinity of the keystone, or crown. *b d*, *c c*, are the *flanks* of the arch. The exterior or top surface is called the *extrados*, or back. The points, *b c*, where the intrados meets the abutments, are called the *springings;* their horizontal distance apart, the *span*; and the distance, *g f*, from the center of this to the center of the intrados, the *rise* or height of the arch.

Fig. 301.



Arch.

The simplest, as it is the earliest, form of arch, is that of a segment of a circle, generally less than a semicircumference, such as is found in the works of the Romans. The Gothic architects about the tenth century originated the pointed arch, formed by two arcs of circles described from different centers, and meeting at the crown. Three and four centered arches were introduced into the later Gothic architecture.

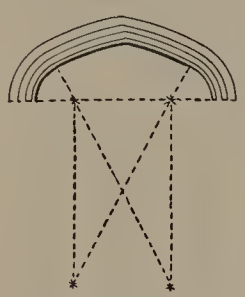
302.

Three-Centered Arch.

In the three-centered arch the lower part to the bends of the haunches was formed by the corresponding opposite arcs of one circle having its center in a line perpendicularly beneath the crown of the arch, the upper opposite sides to the crown being described with equal radii, greater than the radius of the lower part, from centers at equal distances on each side of the perpendicular passing through the crown of the arch.

The four-centered arch was, as its name imports, described from four centers, the two lower centers being perpendicularly under the two upper ones; from the latter are described the lower parts of the arch near the risings, and from the former, with greater radii, the upper parts to the crown; of this form is the Tudor arch, bearing somewhat of a resemblance to the ellipse. The elliptic arch is employed largely in bridge building and in the construction of vaults, drains, etc.

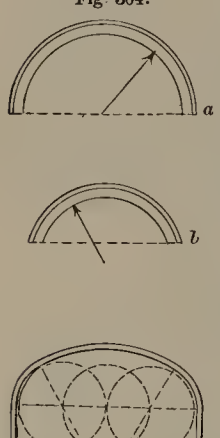
Fig. 303.



Four-Centered Arch.

In Fig. 304 are shown some of the forms of arches employed in architecture.

Fig. 304.



Forms of Arches.

a. The *Semicircular* arch, describing half a circle.

b. The *Segment* arch, struck from a point below the springings.

c. The *Elliptic* arch is not always truly elliptical, but is sometimes formed by the combination of the arcs of several circles.

d. The *Stilted* arch rises from points below its center.

e. The *Horseshoe* arch is peculiar to the Moorish or Arabic style of architecture.

Various styles of pointed arches were employed by the Gothic architects, as shown in Fig. 305.

a. The *Equilateral* arch; so termed because the two springing points and the crown of the intrados form an equilateral triangle.

b. The *Lancet* arch is more pointed than the equilateral arch; and

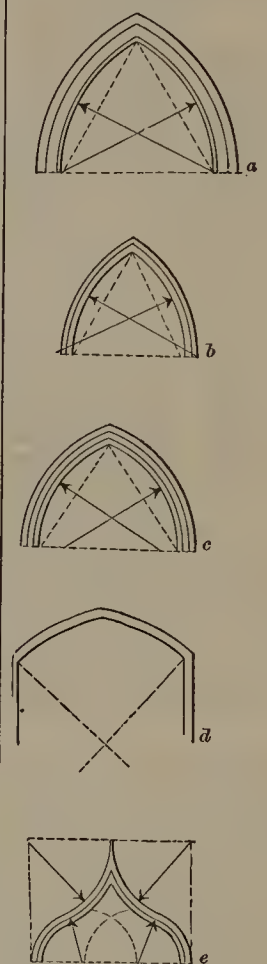
c. The *Drop* arch less so.

d. The *Segmental Gothic* arch is composed of two segments of circles meeting obtusely.

e. The *Ogee* arch was introduced at a later period of Gothic architecture.

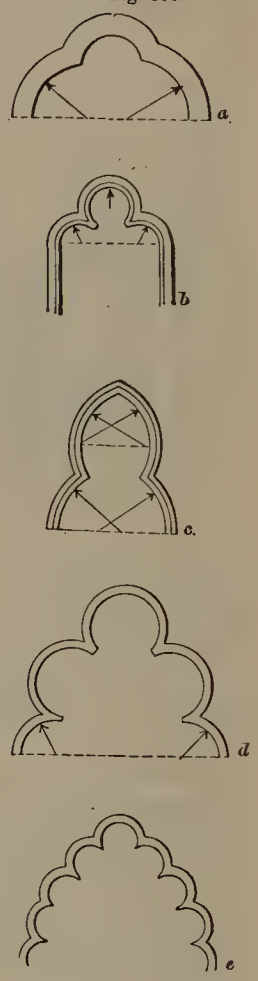
f. The *Tudor* style prevailed during the close of this most graceful order, and was so named from the then ruling family of the English dynasty. It has a much flattened arch, low moldings, and a profusion of panelings.

Fig. 305.



Gothic Arches.

Fig. 306.



Foiled Arches.

Foiled arches, Fig. 306, are so called from the compartments, imitating the *foils* of a leaf, into which they are divided: as, —

a, b, c. Trefoils.

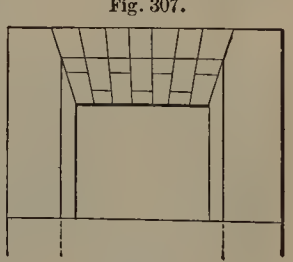
d. Cinquefoil.

e. Polyfoil.

The latter is principally met with in Saracenic and Romanesque buildings.

The *Flat* arch (Fig. 307) is very generally employed in doorways, fireplaces, and windows of buildings; its intrados has no curve, though the voussoirs are arranged so as to radiate to a center, and are laid in parallel courses; where any considerable pressure is to be resisted, it is usually supported by horizontal bars of iron or wood laid across the opening and having their ends supported in the wall on each side.

Fig. 307.



Flat Arch.

In some examples of old date the voussoirs are held up by indented joints which fit into each other. In this form of arch it is manifest that almost the

Fig. 308.

Fireplace of Coningsburgh Castle.

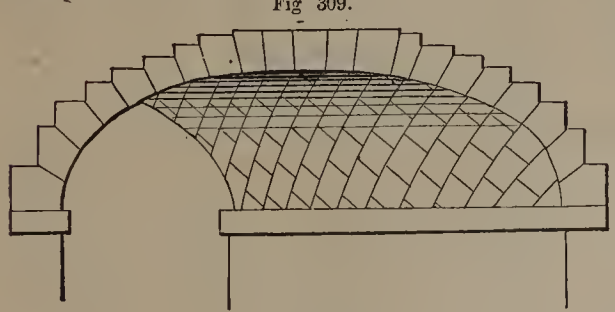
whole pressure is vertical, and that the arch is supported principally by the cohesion of the parts; so that it cannot be used for covering any but narrow openings. As at present employed in brickwork, its principal use is to relieve the pressure on a beam or lintel below it.

Oblique, generally called skew, arches have their axes oblique to their faces, and on account of the difficulty of their construction are seldom employed, unless in railroad bridges where the direction of the line of the road renders it necessary to cross streams obliquely to their courses. In such cases it is necessary that the piers should be parallel to the current of the stream, in order to offer as little resistance as possible and afford a free passage to the water.

A bridge arched in this manner is said to have been built near Florence as early as 1530, but their general introduction dates no farther back than the era of the commencement of railroad construction, about or a little previous to 1830.

The ordinary method of building a skew arch (Fig. 390) is to make it a portion of a hollow cylinder, the voussoirs being laid in parallel spiral courses, and their beds worked in such a manner that in any section of the cylinder perpendicular to its axis the lines formed by their intersection with the plane of section shall radiate from the axis of the cylinder. In this mode of construction the soffit of each stone will be a portion of a cylindrical surface, and the twist of the beds will be uniform throughout the whole of the arch; so that we have only to settle the amount of the twist, and the stones can then be worked with almost as great facility as the voussoirs of an ordinary arch. The *heading* joints, or those which divide the stones of each course, are portions of spirals intersecting at right angles the *coursing* joints, or those which divide the stones of each course, so that the voussoirs are rectangular on the soffit, except those quoins or voussoirs on the faces of the arch where the section exhibited is elliptical.

Fig 309.



Skew Arch.

In Fig. 310, instead of radiating the bed-joints from the center of the cylinder, they are made perpendicular to the curve of the soffit on the oblique section.

Of the parts of an arch, —

The top is the *extrados*, or *back*.

The under-side the *intrados*, or *soffit*.

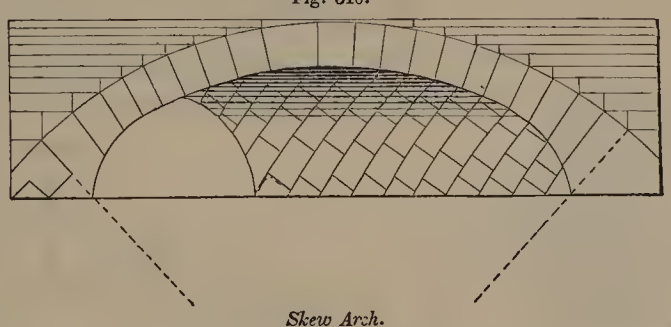
The line from which it commences is the *springing line*.

The stones of the arch are *voussoirs*.

The lower one on each side is a *springer*, or *rein*.

The middle one is the *keystone*, and the course

Fig. 310.



Skew Arch.

the *key-course*.

The upper portion is the *vertex*, or *crown*.

Midway between the *crown* and the *springings* are the *haunches*, or *flanks*.

The *springers*, or *reins*, rest on *imposts*, *abutments*, or *piers*.

The extreme width is the *span*.

The rise of the curve in the center is the *versed sine*, or *rise*.

The space between the *haunch* and the outscribing rectangle is the *spandrel*.

The joints between *voussoirs* are the *abreuvoirs*; which are perpendicular to the surface of the *soffit*.

The exposed vertical surface is the *face*.

An *Annealing Arch* is the oven in which glass is allowed to cool gradually. See ANNEALING.

An *Arabian Arch* is one of horseshoe shape. The diameter is less at the springings than above.

A *Basket-handle Arch* is a three-centered, low-crowned arch.

A *Blind Arch* is a closed arch; one which does not penetrate the structure. Commonly employed for mere ornamentation, to make one face of a building correspond in character with another front where there are actually arched openings.

A *Catenarian Arch* is one in the form of an inverted catenary curve, or that which a chain suspended at each end naturally assumes.

A *Compound Arch* has an archivolt receding in steps; giving the appearance of a succession of receding arches, of varying spans and versed sines.

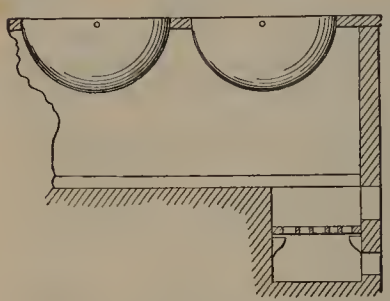
A *Concentric Arch* is one of several courses whose curves have a common center. Common in Norman and Saxon architecture.

A *Discharging Arch* is one which is formed in a wall to protect a space beneath from the superincumbent weight.

An *Arch of Equilibrium* is one in which all parts are of similar strength, and the whole capable of standing without abutments.

An *Arch of Equipollence* is one in which the voussoirs are sustained by mutual opposition; the thrust of the crown being transferred from one stone to another till it reaches the abutments.

Fig. 311.



Furnace Arch.

A *Furnace Arch* is one which spans the fire-chamber and supports a battery of kettles; or it may form the ceiling and roof of a metallurgic furnace, — a *puddling* furnace, for instance.

A *Groined Arch* is one intersected by other arches cutting across it transversely. The point of junction is a *groin*.

An *Inflected Arch* is a reversed or inverted arch.

An *Inverted Arch* is one with the crown downwards, as in the floor of a tunnel, the space beneath an opening in a foundation-wall, etc.

A *Lancet Arch* is a narrow peaked arch, which was much employed for windows during the prevalence of the Gothic style of architecture, known as Early English.

A *Laminated Arch* is one made of successive thicknesses of planking, bent into shape, and secured together by treenails or otherwise. See ARCHED BEAM; LAMINATED ARCH.

A *Rampant Arch* is one whose abutments are on an inclined plane.

A *Relieving Arch* is one on the spandrel of an arch, to distribute and limit the pressure.

A *Skene* or *Schene Arch*, is a circular arch not over 180°.

A *Skew Arch* is one whose line of direction is oblique with its abutment. See Figs. 309, 310.

A *Straight Arch* is one built with voussoirs, which give a level intrados, used as the head of an aperture in a wall.

A *Splayed Arch* is a funnel-shaped arch; one whose two end sections are unequal.

A *Tweer* or *Tuyère Arch* is an arched opening in a furnace-wall at which the blast-pipe enters.

A *Tymp Arch* is the arched opening at which the metal is discharged from a smelting-furnace.

2. (*Mining.*) An unworked portion of the ground.

Arch-board. (*Shipbuilding.*) The part of the stern over the counter, under the knuckles of the stern timbers.

Arch-brick. A compass brick, or one of wedge shape.

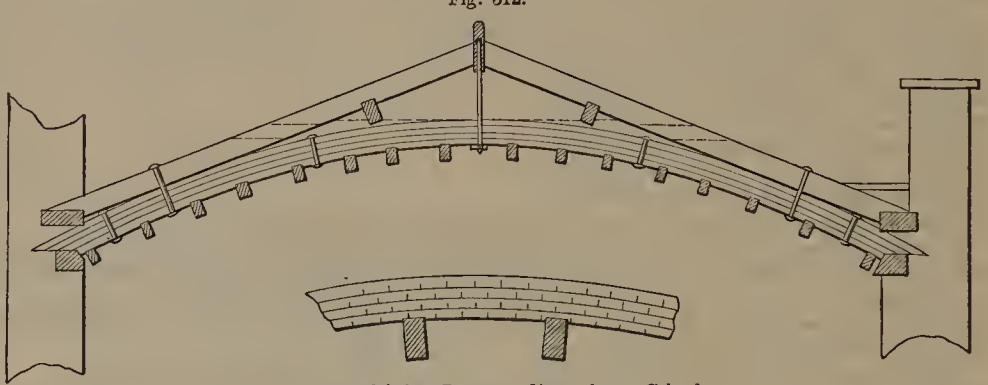
Arch-but'tress. A flying buttress; reaching from the outer wall of an aisle to the clear-story of the nave to form a lateral support against the thrust of the roof.

Arched Beam. (*Carpentry.*) A beam cut, bent, or built into an arched form to support a structure, as a ceiling, roof, or viaduct.

One form of the arched beam is exemplified by the roof of the dining-room of the Charterhouse School, London (Fig. 312). This much-perverted charity is well housed, and the roof of the refectory is formed with circular ribs in four thicknesses of 1½-inch deal four inches wide, with saw-cuts half an inch in depth on the under sides, and put together with *marine glue*, on a cradle center. The dotted lines show the collars, which are dovetailed one inch into the sides of the principal rafters. The principal rafters, being five inches wide, project on one side an inch before the face of the circular ribs, which are only four inches wide. On the collars rest the purlins supporting the rafters. The ceiling joists are spiked up to the circular ribs.

The five main arches of the Ousebourne Viaduct of the Newcastle, North Shields, and Tynemouth Railway, England, are built of arched beams; three

Fig. 312.



Roof over Dining-Room at Charterhouse School.

of these have a span of 116 feet each, and the others have 114 feet span. The hight of the rails above the bed of the stream is 108 feet, and the width of the viaduct is 31 feet, — 26 for a double line of rails, and 5 for a foot-path. At each end of the viaduct are two arches of masonry, and the total length is 918 feet. The two middle piers are erected upon piles from 21 to 27 feet in length. All the piers are of masonry, and tapered upward, the principal being 21 feet wide between the footings and 15 feet at the springing of the arches. The piers are continued upward, of reduced dimensions, to the level of the roadway, the whole of the five main arches, spandreling, and superstructure being formed of timber. The radius of these arches is 68 feet, and their rise or versed sine about 33 feet.

The ribs forming the arches are composed of planks of Kyanized Dantzic pine, the lengths of which vary from 20 to 46 feet, by 11 inches wide and 3 inches thick. The thickness of each rib is made up of fourteen planks so bent as to form an arch, and laid together so as to break joint both transversely and longitudinally. They are fastened together by oaken treenails, 1½ inches in diameter and 4 feet apart, each treenail perforating three of the planks. Between each joint in each direction is placed a layer of strong brown paper dipped in boiling tar.

ARCHED-BEAM ROOF.

PLATE III.

GRAND CENTRAL RAILROAD DEPOT, NEW YORK.

See page 139.

The spandrels are formed of trussed framing, and the platform of the roadway, which is composed of 3-inch planking, is supported upon transverse beams laid 4 feet apart. The platform is covered with a composition of boiling tar and lime, mixed with gravel in applying it, and thus forming a coating impervious to water.

The arched beam has been very extensively used in the timber bridges of the United States. See WOODEN BRIDGE; ARCHED-BEAM ROOF.

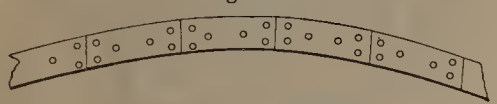
Arched-Beam Bridge. A bridge whose span either consists of a compound beam, or one in which such a beam forms one element in the truss, as in many of the wooden bridges of the last century and the present. See WOODEN BRIDGE.

Compound arched beams of iron are also becoming common, and many beautiful bridges are now made on this principle. See previous article.

The arched beam is now a favorite form of bridge. Angle-iron of varying cross-section is freely used. See IRON BRIDGE.

Arched-Beam Roof. In the sixteenth century Philibert de Lorme, a French architect, invented an

Fig. 313.



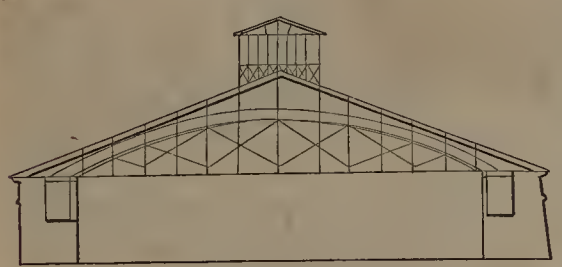
De Lorme's Arched Beam.

arched beam (Fig. 313) made of pieces of timber which were cut into short arcs of the required circle, placed edgewise, and bolted together, breaking joint. Several roofs in Paris and London are, or were, of this construction.

It was a disadvantage of this plan that the pieces were necessarily short, as they would otherwise present a cross grain to the strain.

The largest roof of one span, in its day, was that of the Imperial Riding-House at Moscow, built in 1790

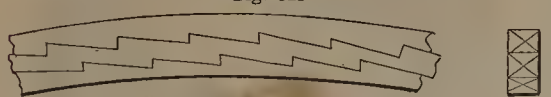
Fig. 314.



Imperial Riding-House.

(Fig. 314). The span is 235 feet. The members of the arched beam are notched together (Fig. 315) so as

Fig. 315.

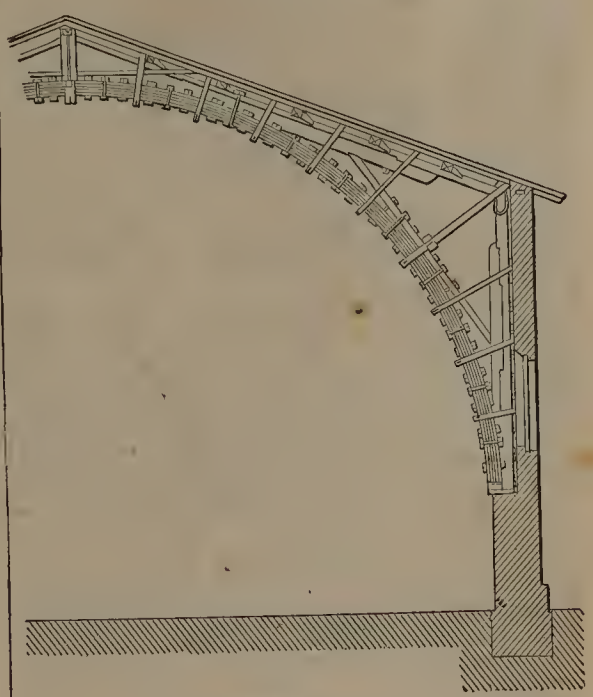


Notched Arch-Beam.

to prevent slipping on each other. The ends of the arched beam are prevented from spreading by a tie-beam, and the arch and tie are connected together by vertical suspension-rods and diagonal braces.

COLONEL EMY'S arched beam (1817) is constructed on a principle differing from both of the foregoing (Fig. 316). The ribs in this roof are formed of planks bent round on templets to the proper curve, and kept

Fig. 316.



Emy's Arched-Beam Roof.

from separating by iron straps, and also by the radiating struts which are in pairs, notched out so as to clip the rib between them.

The principals, wall-posts, and arched rib form two triangles, firmly braced together, and exert no *thrust* on the walls; the weight of the roof, being thrown on the walls at the feet of the ribs, and not at the pole plate, permits the upper portion of the walls to be comparatively light.

The Colonel erected a roof of this description in 1825 at Marac, near Bayonne.

The principle has been extensively adopted in wooden bridges in the United States and in Europe. See WOODEN BRIDGE.

The illustration opposite represents the roof of the Union Passenger Depot of the New York and Harlem Railway, projected by Commodore Vanderbilt, and constructed from the designs of J. C. Buckhout, C. E. The roof is 652 feet long and 199 feet 2 inches between walls. It is supported upon 32 semicircular trusses, which are spaced 20 feet 4 inches between centers, extending from a point 2 feet below the rails to an elevation of 94 feet from the springing line to the extrados of the arch. Each truss has at its foot two tie-rods $2\frac{1}{4}$ inches in diameter, with a turn-buckle at the mid length. The pitch of the roof is formed by rafters secured to the top chord of the arch.

The trusses weigh about forty tons each, and were raised in sections by means of a movable staging 80 feet high, 160 feet long, and 30 feet wide, moving on ways, and shifted along step by step as the work of raising the trusses progressed. About 8,000,000 pounds of iron were used in the structure, 10,000,000 bricks, 20,000 barrels of cement.

The car-house is lighted through three skylights, extending over the entire length of the roof, — one on the center, double-pitched, and a single one on each side of the center, and having altogether 80,000 square feet of glass, — nearly two acres. The north end is closed by an iron front, the south end by the building containing the principal offices of the Company.

The roof covers nearly three acres, the station it-

self about four acres. The station is designed for the use of the Hudson River, Harlem, N. Y. Central, and N. Y. and New Haven Railways, having lines of rail for each company, besides those for the Fourth Avenue horse-cars which run into and to and from this station, which was opened for traffic October 7, 1871. The gas-burners of the building are lighted at night by electricity ; 25,000 feet of electric wire being used, and 20,000 feet of gas-pipe. The 144 steam-radiators are heated by 15 miles of steam-pipe.

The roof is ventilated by six lines of ventilating slats 6 feet high and 8 inches wide, with a Z-shaped interval between the slats.

The roof of the St. Pancras Station of the Midland Railway, England, covers nearly four acres. The roof had at the time of its erection, and may yet have, the widest span of any in existence, 240 feet, and the space beneath is unbroken by ties or braces. Its style is subdued Gothic, with segments meeting at its crown. The roof springs from the platform level, the principal ribs each having the form of a four-centered arch, the radii of the curves being 57 feet and 160 feet respectively. The two central curves — those of 160-feet radius — meet at an angle in the center at a hight of 96 feet above the platform level. The length of the roof is 690 feet, with a clear span of 240 feet, covering five platforms, ten lines of rails, and a cab-stand 25 feet wide, thus making a total area of 165,600 square feet. Its hight at the ridge is 125 feet above the level of the road. There are twenty-five principal ribs in the roof, 29 feet 4 inches apart from center to center, and each weighing about 50 tons. The station walls rise, behind the spring of the principal, the space at the top being filled in with open ironwork.

The roof is glazed about 70 feet on each side of the center, and the remainder is covered with slates.

The transverse girders which support the floor of the station take the thrust of the roof. They are connected so as to form continuous girders across the station, and rest on the walls of the 17½-feet story beneath. Besides being tied to the girders, the feet of the ribs are each secured by four 3-inch bolts to an anchor-plate built into the wall and strongly fastened.

Arched But'tress. A flying buttress, or *arc-boutant.*

Ar'chil. The extract of Orchilla weed, used for dyeing, usually evaporated so as to form a solid mass like indigo. Called also *Orchil* and *Cudbear.*

Ar'chi-me-de'an Drill. A drill whose stem consists of twisted pinion wire, or a core having steep spirals. A nut with internal oblique grooves is reciprocated on the stem and rotates the latter. A PERSIAN DRILL (which see).

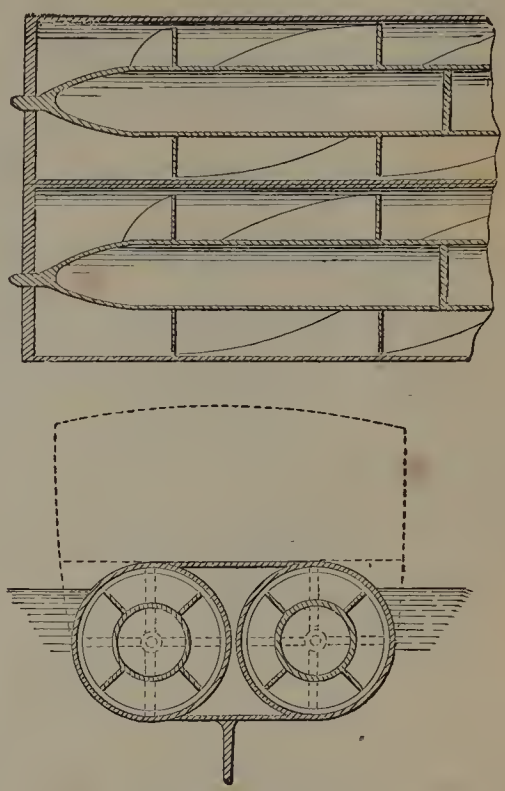
Ar'chi-me-de'an Pro-pel'ler. A propeller consisting of a continuous spiral vane on a hollow core running lengthwise of the vessel. It is an amplification and extension of the screw. Figure 317 shows it in horizontal and transverse sections. See SCREW PROPELLER.

Ar'chi-me-de'an Rail'way. A form of railway in which a continuous shaft rotates on pillars erected between the lines of rail, the shaft having a spiral rib which acts as a screw upon a pedestal below the car to propel it along the track.

Ar'chi-me-de'an Screw. The invention of Archimedes when in Egypt, about 260 B. C. It consists of a hollow inclined screw, or a spiral pipe around an inclined axis ; the lower end is submerged in the water and the upper end discharges.

Strabo refers to a water-raising machine of this kind, used to supply the garrison of the Memphite Babylon, on the Nile, and worked by 150 men.

Fig. 317.



Archimedean Propeller.

It was also used as a draining pump by the Turdetani of Iberia in the time of Strabo. This was the country of the Guadalquiver. See SCREW, ARCHIMEDEAN.

Ar'chi-tect'ure. The classic orders are five : *Doric, Ionic,* and *Corinthian* (*Greek*) ; *Tuscan* and *Composite* (*Roman*). The more modern is *Gothic,* which has several varieties : *Anglo-Roman,* B. C. 55 to A. D. 250 ; *Anglo-Saxon,* A. D. 800 to 1066 ; *Anglo-Norman,* 1066 to 1135 ; *Early English or Pointed,* 1135 to 1272 ; *Pure Gothic,* 1272 to 1377 ; *Florid,* 1377 to 1509 ; *Elizabethan,* 1509 to 1625. The subject is copiously and admirably treated in many excellent works. Its interest in a work of this character is not as an art, but as requiring machinery to hew and shape the stones, construct the foundations and the roof, and also calling for ingenuity in providing the building with its material accessories for safety, ventilation, warmth, light, and convenience.

The following are dates assigned by some authorities for the buildings mentioned : —

The Pyramids	(about) B. C.	1500
Memnonium	"	1350
Solomon's Temple	"	1004
Birs Nimroud,	"	900
Jupiter Capitolinus	"	616
Parthenon	"	438
Pantheon	A. D.	13
Coliseum	"	70
St. Sophia	"	532
Mosque of Omar, at Jerusalem	"	637
Caves of Ellora	"	700
St. Peter's, Rome	"	1626
St. Paul's, London	"	1710

The *tent* is the original of the Chinese style.
The *cave* is the original of the Egyptian.
The *log cabin* suggested the Grecian.
The *avenue of trees* the wondrous Gothic nave.
The possession of iron and various facilities of

work have yet inspired no one. Some are anxious to build iron houses as much like stone as possible; the most ambitious attempt is an immense barn at Sydenham, England, — an engineering success, but not a work of inspiration.

The Egyptian capitals were the prototypes of those of the Grecian and Roman orders; and the various ceramic works of the Greeks and Etruscans were strangely like those of the Nile people. The opening of the Egyptian ports by Psammeticus, 670 B. C., was fortunate for the nations on the northern shore of the Mediterranean.

For Specific Index of ARCHITECTURE, see MASON'S AND BRICKLAYER'S WORK.

Ar'chi-ton-nere. A name for the STEAM GUN.

Ar'chi-trave. (*Architecture.*) That portion of an entablature which rests upon the columns; the *lintel.*

(*Carpentry.*) The molding around a doorway or window. The respective portions are known as the *transverse architrave,* and *architrave jambs.*

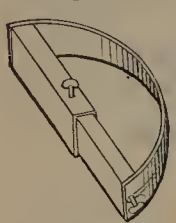
Ar'chi-volt. (*Architecture.*) *a.* A molding running round the face of an arch.

b. The inner curve formed by the voussoirs or arch-stones.

Arch'-stone. A wedge-shaped stone used in an arch; a voussoir. In some furnaces the chamber, or an opening thereinto, is covered by a flat ashlar, which is called an arch-stone.

Arc'o-graph. An instrument for describing arcs of circles without the use of centers. A thin and pliable strip of metal whose ends are attached to the wooden bar may be sprung into the required shape and then fastened by set screws. Unless the stock have means for extension and contraction, the range of arc which may be described will be but limited. The device is susceptible of many variations, and is useful as a templet or marker for many purposes.

Fig. 318.



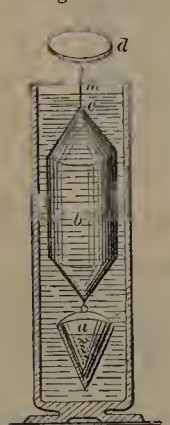
Arcograph.

A-re-om'e-ter. An instrument used by the Spanish Saracens A. D. 1000. It had a bulb and stem similar to a hydrometer; floating in liquid, its stem was more or less submerged by the changes in the density of the liquid due to changes of the temperature, and thus constituted a thermometer.

NICHOLSON'S areometer consists essentially of the funnel *a*, the cylinder *b*, rod *c m*, and the table or plate *d*.

The instrument is so arranged that when set in distilled water and a definite weight laid upon *d*, it will sink to a mark *m* made on the rod. To determine the specific gravity of a mineral, it is laid on the plate *d*, when it will of course depress the instrument in the water. Additional weights must be added to bring the mark *m* to the level of the water, and the amount of these subtracted from the standard weight already referred to will be the weight of the mineral in the air. Call this weight *p*. Remove the mineral from the plate, and place it in the funnel or hollow cone *a*; immersed in the water the areometer will not sink quite to *m*, say about to *c*, the body losing in water an amount of weight equal to that of a quantity of water of precisely the same volume with itself, that is, equal to that of the water displaced. Additional weights are now to be laid on *d* until the level *m* is again reached. This amount, which we will call p', expresses the weight of an equal volume of water. We have thus ascertained the weight of precisely equal volumes of water and of the mineral, and as water is the standard taken, $\frac{p}{p'}$ will express the ratio of the two, or the specific gravity of the body.

Fig. 319.



Nicholson's Areometer.

Thus, $x : 1 :: p : p'$, and $x = \frac{p}{p'}$.

The areometer of PAPPUS, the Greek philosopher contemporary with Theodosius the Great, A. D. 379 – 395, is described by Al-Khâzinî the Saracen, an eminent writer of the twelfth century, the author of the "Book of the Balance of Wisdom," and suspected to be identical with the great Al-Hazen, whose celebrity is associated with the Cordovan period of Spanish history. It was a graduated brass tube which floated vertically in liquid and indicated by the line of submergence the degree above or below the "equator of equilibrium," the specific gravity of the matter weighed.

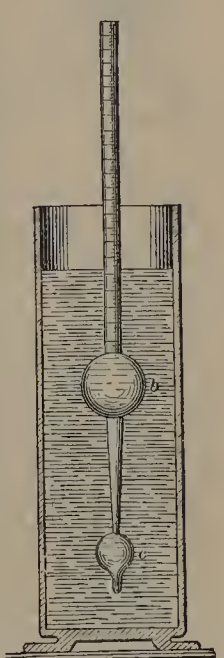
The surmise of Chev. Khanikoff, indorsed by Draper, that Abu-Jafar Al-Khâzinî and Al-Hazen were identical may be correct. They were certainly contemporaries, but the former, whose name it is impossible to find in any other part of the Persian annals, fails in some respects to answer for 'Abu-'Alî Muhammad Bin 'al-Hasan 'Ibu 'al-Haitham, said to be of Basrah.

The book referred to above as the writing of Al-Khâzinî was composed, as is seen in the Dedication, at the court of the Saljûke Sultân Sanjar, who reigned over a large part of the ancient Khalifate of Baghdâd from A. D. 1117 to 1157.

The areometer of Pappus is very similar to the *Volumeter* of Gay Lussac.

GAY LUSSAC'S scale areometer consists of a cylindrical glass tube in the lower part of which a ball *b* is blown, and, being continued, finally terminates in another ball *c*. The latter is filled with shot or mercury, to cause the instrument to sink vertically in distilled water to a certain point, the zero. The specific gravity of a liquid is ascertained by the depth of depression, its weight being equal to that of the liquid displaced. It is a form of hydrometer.

Fig. 320.



Gay Lussac's Areometer.

A-re-o-sty'los. An intercolumniation of four diameters width.

Ar'gand Gas'-burn-er. The Argand Gas-burner has a circular series of holes on the upper edge of a cylindrical chamber, having a central aperture to allow access of air to the inside of the flame.

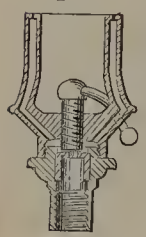
The jets from the series of holes unite to form a cylindrical flame. The holes are about one sixth of an inch in diameter, and when there are ten holes in the circle, the middle opening will be four tenths of an inch in diameter; with twenty-five openings, the central aperture will be about one inch in diameter.

The following formula is given for the number of holes, central aperture, hight of flame without smoking, and appropriate size of chimney: —

No. of Apertures.	Central Opening.	Hight of Flame.	Diameter of Glass Chimney.
	inch.	inch.	inch.
10	$\frac{3}{8}$	$3\frac{1}{2}$	$\frac{8}{10}$
15	$\frac{1}{2}$	3	$\frac{12}{10}$
20	$\frac{3}{5}$	$2\frac{1}{2}$	$\frac{13}{10}$
25	$\frac{19}{20}$	2	$\frac{15}{10}$

In Fig. 321 the lower section of the burner has an orifice for the gas, which is more or less obstructed by the end of a screw which is either turned directly by hand, or, when vertical and inclosed within the burner, is turned by a lever projecting through a slot therein.

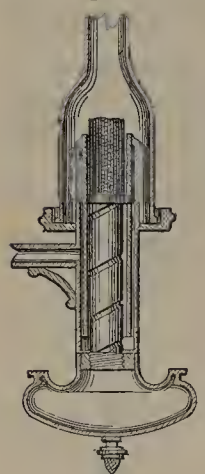
Fig. 321.



Argand Gas-Burner.

Ar'gand Lamp. Invented by Argand, a native of Geneva, about the year 1784. It consists of two concentric cylindrical tubes between which is fitted the annular wick used in this peculiar burner. The annulus inclosing the wick is closed at the bottom, and communicates, by a pipe, with the oil reservoir. The interior tube being open, free access of air is allowed to the interior and exterior of the flame, insuring more equal and perfect combustion.

Fig 322.



Argand Lamp.

In a round solid wick, burning any of the fatty oils, such as sperm, a large proportion of the carbon, which in that class of oils is greatly in excess of the hydrogen, escapes unconsumed and is wasted, rising in the form of smoke.

The annular wick has double the surface of a solid one of the same diameter exposed to the contact of the atmosphere, and as the flame is also thinner its temperature is more uniform, and the vapor from the center of the wick is consumed equally with that from its exterior. The combustion is also greatly aided by the draft caused by the glass chimney, continually bringing fresh supplies of oxygen in contact with the flame and protecting it from currents of air. The chimney was the invention of L'Ange.

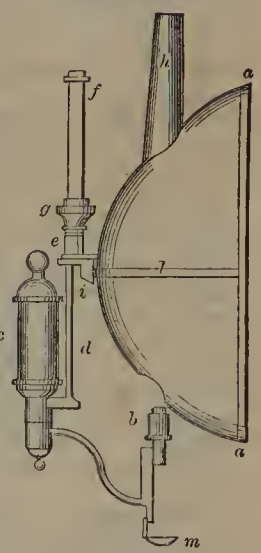
Argand died in 1803. A French mechanic named Carcel patented an improvement in 1800, in which the oil is pumped from the reservoir to the wick by power derived from a spring or by the ascending column of air above the chimney. This is called the *Mechanical Lamp*, and is used in the large lamps for the Dioptric system in lighthouses.

The Argand burner as modified by Fresnel for the Dioptric system in lighthouses has four concentric wicks, the outer one $3\frac{1}{4}$ inches in diameter, and the great heat produced is carried off by two means, — overflowing the wicks with oil, and by means of the ventilator devised by Faraday. The oil in superabundant quantity is pumped into the wick-tubes and flows over the top. The ventilator is a tube having several sections, the lower portion of each being flaring, and receiving the upper end of the section below, which enters it a short distance. The top of the lamp-chimney enters the lower section and produces a great draft.

The Argand lamp first made effective the Catoptric system for lighthouses.

The annexed engraving shows the lamp in its lower position, withdrawn from its place in the focus of the paraboloid reflector *a* for trimming. *b* is the burner, and *c* a cylindrical fountain containing twenty-four ounces of oil. The oil-pipe, burner, and fountain are connected to a frame *d*, which is movable in a vertical direction upon guide-rods *e f*, by which it can be let down by simply turning the handle *g*.

Fig. 323.

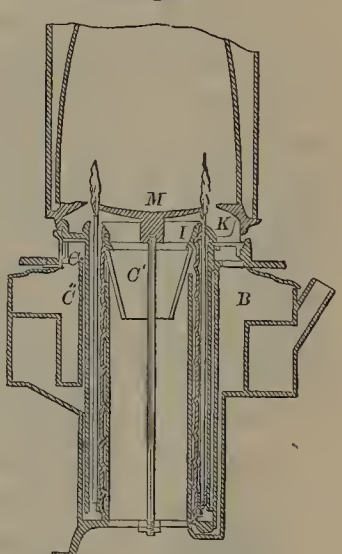


Argand Lamp.

An aperture of an elliptical form, measuring about two inches by three, is cut in the upper and lower part of the reflector, the lower serving for the free egress and ingress of the burner, and the upper, to which the copper tube *h* is attached, serving for ventilation; *i* shows a cross-section and a back view of the main bar of the chandelier or frame on which the reflectors are ranged, each being made to rest on knobs of brass, one of which is soldered to the brass band *l*, that clasps the exterior of the reflector. *m* is an oil cup to catch drip. A frost lamp is placed at this point in winter to keep the oil in the wick-tube in a flowing condition.

The tubular wick-burner (Fig. 324) has a water-chamber *B C''* interposed between the wick-tube and the oil-reservoir, so as to prevent the heating of the contents of the latter. The wick occupies an annular space formed by two concentric wicks. *M* is the deflector plate, and *C' I* a frustrum to reflect upward the heat which reaches the inside of the tube. *G''* is a perforated floor to prevent the conduction of flame, on the principle of Davy's safety-lamp. The water has an overflow down the central air-tube. *K* is the base ring for the chimney.

Fig. 324.



Dopp's Argand Lamp.

Ar-gent'al Mer'-cu-ry. Silver amalgam.

Ar'gen-tan. An alloy of nickel copper and zinc. ALBATA; GERMAN SILVER (which see).

Ar'gen-tine. White metal coated with silver.

Ar'gen-tine Glass. An ornamental glassware having the sheen of silver. It is the invention of Apsley Pellatt, and is formed by inclosing delicate white Argentine incrustations of dry porcelain clay with solid and transparent glass.

The dry figures are placed on a red-hot bulb of flint glass and immediately covered with a thin layer of very fluid glass.

The exterior layer is polished, and gives a silvery brightness to the white figure.

Ar-gen-tom'e-ter. A graduated tube used for ascertaining the amount of silver in a solution by the admission of a definite bulk of chloride of sodium solution.

Ar-gen'tum Mo-sa'i-cum. An alloy, or rather *amalgam*, of tin, bismuth, and mercury, used for coloring images of plaster of Paris. *Argentum Musivum.*

Ar'gil. Potter's clay, from the Latin *argilla ;* white clay.

Ar'go-sy. A merchant-ship of the Mediterranean ; specially of the Levant. The term is now antiquated..

A'ri-es. The battering-ram, so called because the metallic head of the beam was sometimes fashioned like the head of a ram. As a means of battering walls it is said to have been invented by Artemanes of Calzomene, a Greek architect, about 441 B. C. It is described by Josephus, who states that it was sometimes supported on the shoulders of men who advanced on a run ; at other times it was slung from a frame, and operated by ropes.

Philip of Macedon is said to have been the first to place the frame on wheels, at the siege of Byzantium. Plutarch informs us that Marc Antony, in the Parthian war, made use of an aries 80 feet long. Vitruvius says they were sometimes 106 to 120 feet in length.

A-rith-mom'e-ter. An instrument for assisting in calculating. The most ancient form is the Abacus (which see). This has a series of wires, the balls on which represent units, tens, hundreds, etc., and is used by sliding the balls on the wire, to tabulate the result of each successive increment or decrement of numbers.

If the balls were numbered and several series were strung upon a ring, they might be passed continuously in the same direction, as the addition required.

The Arabs, to whom we are indebted for the introduction of the Indian numerals, termed their treatises "Systems of *Indian* Arithmetic." The word *cipher* is the Arabic *tsaphora*, — "blank" or "void" ; alluding to its integral value. The word *algebra* is also Arabic. The words *chemise*, *cotton*, are alse Arabic, and to the Arabs Europe is also indebted for the introduction of the garment and the material. Mohammed Ben Musa wrote a treatise on algebra in the latter part of the ninth century. The Khalif Al-Maimon measured a degree of latitude on the Red Sea shore. This, when the teachings of Constantinople and Rome were on the scale and standard of Byron's Grand Seignoir, —

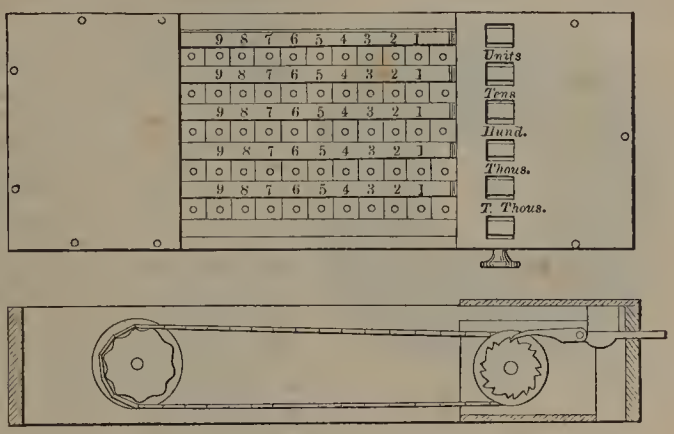
> "He knew, because he saw, the moon was round,
> Also was certain that the earth was square." — *Don Juan.*

An arithmometer was suggested by the Marquis of Worcester in his "Century of Inventions," but was not described. It was adapted for addition and subtraction.

Sir Samuel Morland, in 1672–73, published a treatise on the use of two arithmetical instruments adapted for addition and subtraction.

In Fig. 325, instead of balls on a wire, a series of sectional belts operate numbered wheels, which are rotatable in one direction only. The numbers on the peripheries of the wheels are exposed at a row of openings in the case. The sections of the belt are perforated so as to be moved by a peg, the selection of the place for the peg being assisted by a row of numbers over each belt.

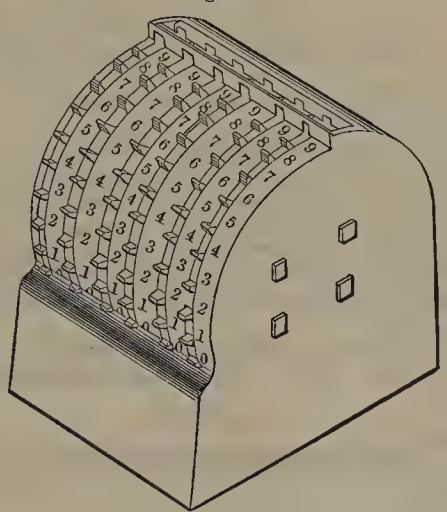
Fig. 325.



Computing Machine.

The Calculator (Fig. 326) has disks numbered on their peripheries and arranged on a common axis.

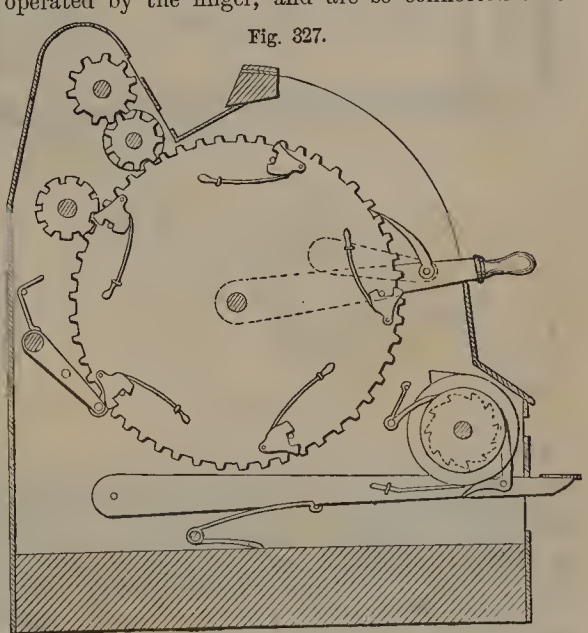
Fig. 326.



Calculator.

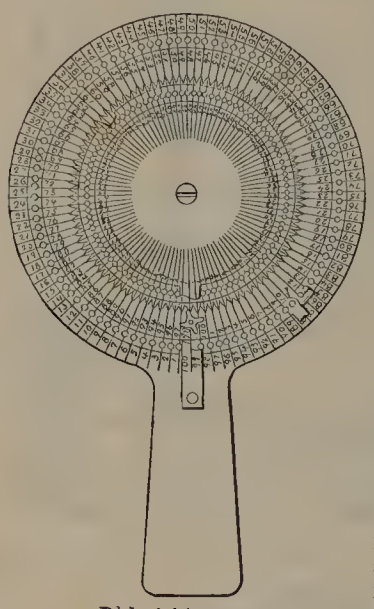
They are moved by cogs exposed conveniently to be operated by the finger, and are so connected that

Fig. 327.



Arithmometer.

Fig. 328.



Disk Arithmometer.

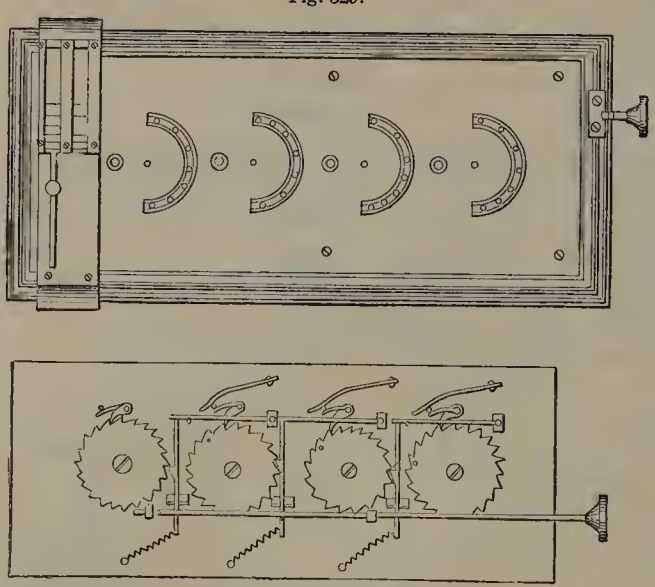
the motion of ten cogs on the disk of units gives the next disk a single impulse and registers ten, and so on through the series. The result is visible at a slit in the case.

Fig. 327 has also the numbered disks, which are moved by handles sweeping in circular arcs. It performs the operations of addition, subtraction, multiplication, and division, the results appearing at different slits in the case. Space will not permit an exact elucidation of the mode of operation of this ingenious machine.

Another form of arithmometer is that in which disks of varying diameters overlie each other, and communicate motion to each other in regular series, as in Fig. 328, the units to the tens, these to the hundreds, etc. The principle is substantially the same as those previously described, but the device has a compact appearance, and the result is read on a dial.

One other form is analogous to the disks of a gas-meter register, which is in fact an arithmometer.

Fig. 329.



Ciphering Machine.

See Fig. 329. The different disks are arranged on their separate axes, and usually have their numbers on their circular faces. A revolution of the unit wheel gives one tenth of a revolution to the wheel registering tens, and so on; the numbers of the wheels appear at the series of openings in the slit, and are read consecutively. In the gas register the impulse is all imparted to the unit wheel, and from it is transmitted through the series; but in adding machines each wheel must have capacity for independent rotation to register thousands, hundreds, tens, and units, not affecting those below it of lesser denomination, but each imparting to the one above it one tenth of its own motion.

Registering devices are to be seen very perfectly constructed in steam-engines and printing-presses; in the former to record the number of revolutions of the shaft for economical purpose in estimating the consumption of steam, the slip of the paddles, etc., and in the latter case for keeping record of the number of impressions. See CALCULATING MACHINE, BABBAGE'S.

Ark. A flat-bottomed boat made of a frame and boards which do not usually overlap, but are nailed to the frame and have the interstices calked or daubed.

It is used on the Western rivers to transport produce, pelts, merchandise, etc.

Ar-lien-ans'e. (*Fabric.*) A kind of Spanish linen.

Arm. (*Angle-Iron.*) 1. One of the wings or flanges of angle-iron. The side-arm of the angle-iron in a ship's frame forms the *faying*-surface to which the plates are riveted. The other arm is in the plane of the transverse section of the vessel.

2. (*Knees.*) One of the members or projections of a *knee*. With *timber* knees, the arms are usually two, resting respectively against the *beam* and the ship's sides. With *iron* knees, the arms may be more numerous, and may embrace other sides of the object to which they appertain.

3. (*Nautical.*) One of the projecting members of an anchor, terminating in a *fluke* or *palm* which takes hold on the ground.

The *arms* unite at the *crown*.

The *throat* is at the junction of the inner edge of the *arm* with the *shank*.

The *trend* is that part of the *shank* reaching from the *throat* towards the *stock*, a distance equal to the length of the *arm*.

The *pee* or *bill* is the point of an arm.

4. The outer piece of an overshot water-wheel bucket. Also called the wrist. The inner piece is the *floor* or *bottom*. See BUCKET.

5. (*Vehicles.*) That part of the axle which passes through the hub of the wheel. The *axle-spindle*. When of wood, it is strengthened by metallic straps called *skeins*, and sometimes by a conical sheath called a *thimble-skein*.

In carriages it is of iron, in continuation of the iron axle, or it is inserted into the end of a wooden axle. See AXLE.

6. Of a hammer. The handle of a trip-hammer, which receives the impulse of the cams.

7. Of a windmill. The beam which supports a sail; the sail itself; also called a *whip*.

8. A spoke of a gear-wheel.

9. An end of a yard.

10. A weapon; as, *side-arm*, *fire-arm*, *small-arm*.

Arm, Ar-ti-fi'cial. Artificial arms are adapted for amputations above or below the elbow, respectively. In the former case the movements, in the most perfect artificial arms, are derived from the motions of the stump; the backward motion of the latter extending the joints of the prosthetic arm and hand, and the forward motion of the stump flexing the said joints. These motions are derived from bars or

cords which connect the forearm to a shield on the shoulder, as in Koeller's, or to bands on the body, as in Condell's and in Uren's.

In these cases the upper arm consists of a socket to receive the stump of the limb, and is secured by straps to the person with a certain degree of rigidity. The anterior and posterior tendons or rods have a firm attachment at or near the shoulder, pass along or through the upper section, and are attached to such points on the forearm that, as one or the other is tightened, the forearm is flexed or extended. In some cases the oscillation or the elbow-articulation is obtained by cords which have direct or intermediate attachment to the forearm, as in Condell's and Peterson's; in others the cords or bars move a toothed wheel which engages a pinion on the elbow axis and gives motion to the forearm, as in one of Koeller's.

The backward motion of the stump, it will be apparent, tends to strain the anterior tendon, which is so connected to the forearm behind the elbow-joint as to extend the forearm. The forward motion of the stump strains the posterior tendon which connects to the forearm in front of the articulation, and thus flexes it as the stump is moved forward. These motions follow the natural ones, as, for instance, in the act of raising the hand to the mouth it is usual to oscillate the arm forward on the shoulder as a pivot, and backwardly as the hand descends. In the natural arm the pivotal position of the forearm is varied so as to cause the said arm to swing in an arc which will bring the hand to the required place, say the mouth, for instance; in the artificial arm, the motion on the shoulder is the generator of the motion on the elbow, and a certain amount of practice and adjustment is required to proportion the parts so that the consentaneous action of the parts which produce the compound motion may, without apparent constraint or indecision, land the hand at the object. When the trunk of a person affords points of attachment for the flexor and extensor straps, the motions of the shoulder itself, relatively to the thorax, and involving the clavicle and scapula, may be made to assist in executing the motions required.

The primary motion of the stump having been communicated to the forearm by the means described, (and the special devices are various and very ingenious,) the motions of the hand are derived from that of the forearm by means of tendons, slides, or other attachments. The construction will farther appear when considering some of the varieties of artificial arms, though it will not be possible to afford space for an exhaustive description even of the sixteen patents which have been selected and are now before the writer.

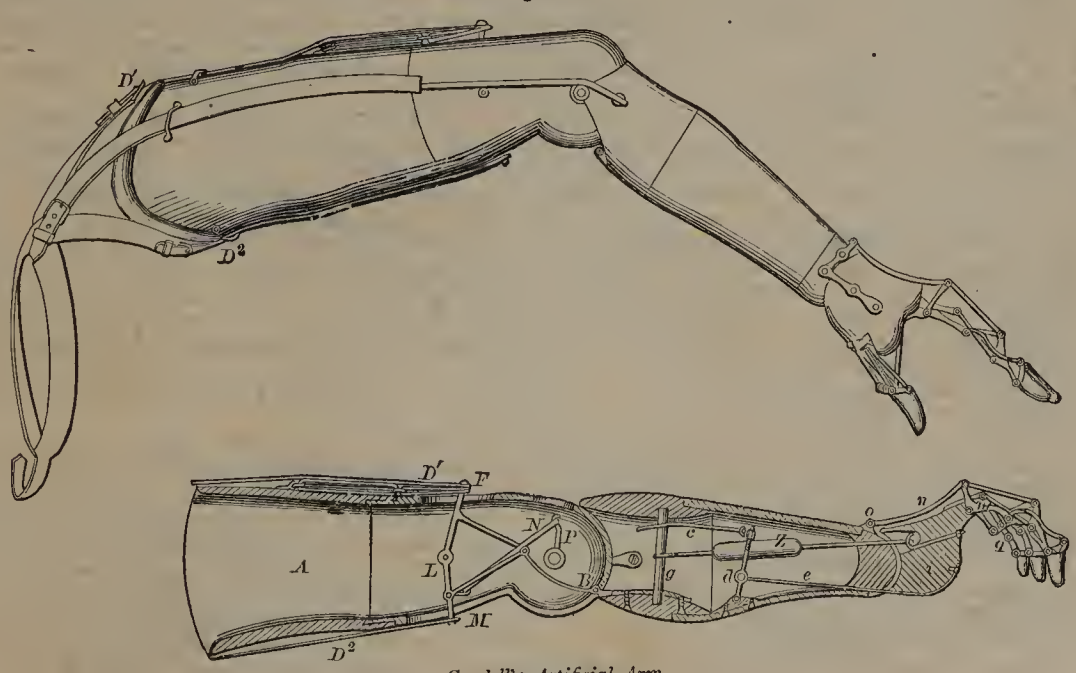
One class of arms does not receive motion from the stump, but retains the position at which it is set by the other hand, or assumes and retains it by swinging it in one direction or the other till it is engaged by a spring latch. Drake's, also Lindsay and Vance's, are illustrations of the former; Lincoln's of the latter.

To secure the requisite lightness and afford room for the operative devices, artificial arms are made hollow. The material is various, and some patents have been issued for the use of specific materials, such as rawhide, which has a toughness and strength hardly to be excelled. Vulcanite, papier-maché, layers of fabric alternating with glue, veneers, cardboard, and hollow wooden blocks shaped to the natural contour, have all been advocated and used.

The tubular form does not always extend to the metacarpus, and the fingers especially are frequently made of solid jointed blocks, with tendons, cartilage, and ligaments. These prosthetic parts perform the functions of their correlatives, as being the means of motion, giving resiliency to the contact of the parts, and specific connection to the phalanges. In the latter case, the hingeing of the parts, it must be admitted that the human mechanic has assumed a hard task in attempting to copy the natural articulations, and that he has done commendably with the materials at hand.

In CONDELL'S arm the loop appendage is a yoke of webbing for the attachment of the socket to the stump, and for securing such a rigid connection to the body that the three straps proceeding down the humerus may be utilized when the stump is moved backward, forward, or rotated, in producing extension

Fig. 330.



Condell's Artificial Arm.

and flexion of the arm and the forward motion of the metacarpus which opens the phalanges. The axis moves with the forearm, and a stud P thereon affords a point of attachment for the spring N, whose duty is to assist in extension. The straps D' D^2 are respectively attached to the yoke in posterior and anterior positions, and to the arm of the rock-shaft L at F and M respectively. The draft on D' acts to flex, and on D^2 to extend, the forearm, by means of the link B, which is pivoted to the forearm anteriorly. The flexor and extensor motions described apply to the forearm, but do not involve the action of the hand, the metacarpus of which is hinged by a through pin to the mid-wrist. A post g is permanently attached in the hollow of the arm, and a spring tendon Z passes from it to a point on the metacarpus back of its wrist articulation, so as to oscillate it backwardly. This spring being constant, the normal position of the metacarpus is rearward and the fingers and thumb closed. The relation of the motion of these to that of the metacarpus will be presently described. The forward motion of the hand and the opening of the grasp are effected by a slight rotation of the shoulder, which draws upon the strap c, oscillates the post d, and by means of the tendon e draws forward the metacarpus extending the phalanges.

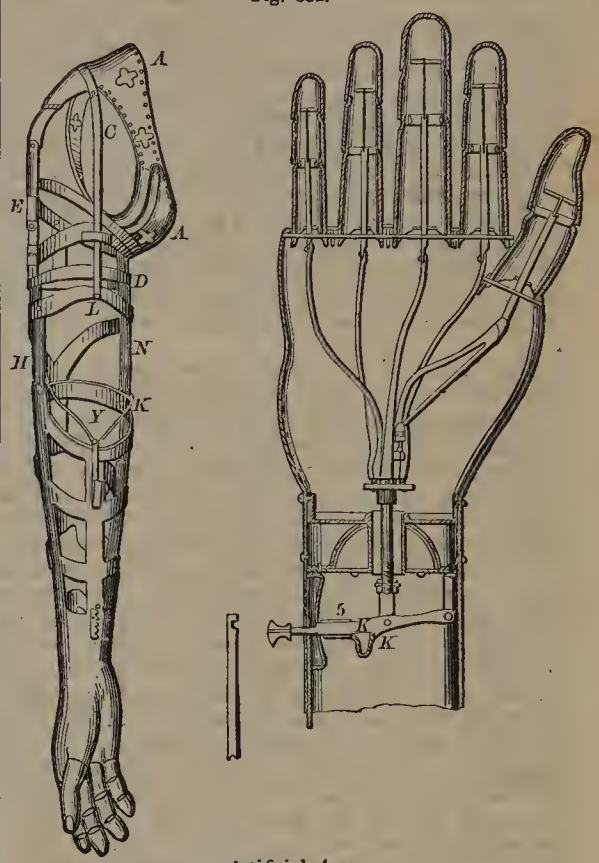
The forward portion of the forearm is sleeved upon the butt or wooden part in which the post g is secured. By the partial rotation of the forward portion the ulna-radial motion is given (by the other hand), to vary the presentation of the palm ; the tendons which actuate the metacarpus still maintaining the same relation, that is, having their points of attachment thereto at opposite sides of the axis of vibration.

The frame-piece m of each finger is pivoted to a point on the metacarpus i, and the rod at the back of the hand is pivoted to the frame-piece and also to a point on the forearm at o, so that when the metacarpus is moved, by the means previously described, the frame m is oscillated on its pivot, and gives the primary deflection to the finger. The second section of the finger-frame is pivoted to a point on the frame m, and is connected by a link to a stud permanently attached to the metacarpus ; by this means is obtained the additional deflection proper to the second phalange. The additional deflection due to the third phalange is given by a rod attached to it and to the frame-piece m. The same arrangement is adopted for each finger, and the action of the phalange is cumulative, the second and third phalanges participating in the motion of the first, and having an additional motion derived therefrom ; the third in like manner participates in the motion of the second and third, and has a motion of its own derived from its predecessors. The proportion of the parts of respective fingers is so regulated that, in closing, the second, third, and small fingers receive a gradually accelerated motion in the order stated, so as to imitate the natural closure of the hand, in which the little finger most nearly approaches the palm and the others stand in receding order.

The motions of the thumb are substantially equivalent, being derived from its diverse points of attachment to the metacarpus and to a point on the forearm, so as to be closed by the backward motion of the former, and conversely, as already stated in regard to the phalanges of the fingers.

In Fig. 331 the shoulder-cap is the basis for the movements of the arm, forearm, wrist, thumb, and fingers. The strap C is hinged to the cap A, and connected by a rod to the ring L. The straps D E of the upper arm are also hinged to the cap and the lower part of the upper arm ; from the ends of the straps D E proceed the slotted bars H N, to whose

Fig. 331.



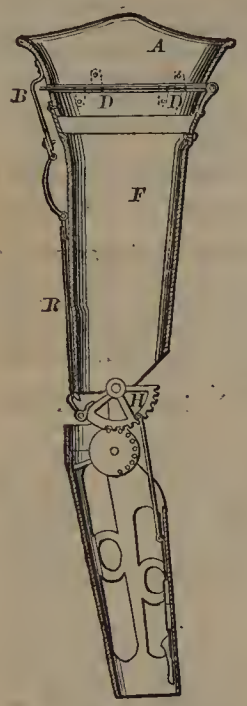
Artificial Arm.

lower end the forearm is pivoted. The three straps mentioned are the means of suspension of the arm, forearm, and hand, and the stump of the natural arm within this outer skeleton is the means of imparting motion to the forearm, wrist, and fingers. The ring L is connected to the strap C, and hinged to the forearm behind the elbow-joint ; it is guided in its motions by the slotted bars H N, sliding down the said slots as the stump is moved forward, and thereby thrusting upon the point of the elbow and flexing the forearm.

Pivoted to the bars H N, near the elbow-axis, are the bifurcated ends of the wire Y, which actuates the fingers and thumb, flexing them as the arm bends, by means of tension on the tendons which pass through the metacarpus and then diverge to follow the phalanges. By means of the lever K, the spring-slide 5, and the notched slot, the thumb and fingers can be connected to or disconnected from the arm and forearm, so as to receive motion therefrom, or otherwise as may be desired. In the rotary movement of the stump the upper end of the strap D runs on a rod attached to the shield A under the axilla.

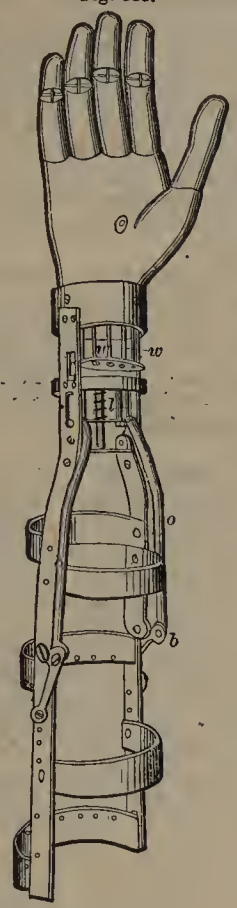
Fig. 332 is for amputations above the elbow. The shoulder-joint is imitated by a cap or collar and a hoop which turns on the collar by looped brackets, which slide upon a wire ring suspended to the lower edge of the collar. The case which holds the stump is attached to the hoop by a hinged joint, and turns with it. The motions of the stump, whether rotary or back and forth, turn the hoop, and by means of a system of jointed levers, the fixed points of which are on the collar, and the case for the stump, motion is

Fig. 332.



Artificial Arm.

Fig. 333.



Artificial Arm.

communicated to a segment-wheel at the elbow-joint to which the levers are attached, and this wheel, acting upon a pinion on the forearm, causes it to be flexed and extended according to the motions of the stump.

The hoop *D D* slides on the collar of the artificial shoulder *A*, the two portions being bracketed to a ring *B* between them. The hinge motion of the shell *F* of the upper arm is effected by the stump, and the segment-gear, *H*, being linked posteriorly to the shoulder-piece, is rotated by the motions of the upper arm, which tighten or slacken the said link-connection *R*.

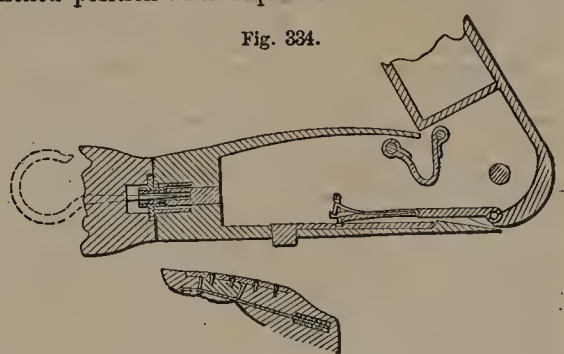
In Fig. 333 the flexion of the forearm operates the fingers, and the spring in the wrist tends to close them. To studs *b* on the upper arm are attached rods *o o*, which connect with a sliding plate in the wrist, to which the flexor rods *w w* of the fingers are attached. The elbow connection of the rods *o o* is in the rear of the elbow articulation of the limb, and the forward motion of the forearm draws upon these rods so as to flex the fingers against the force of the spring *l*, which assists in the return extension.

In each finger is an arrangement of rocking rods by which a positive motion is imparted in consonance with the motions of the slide in the wrist. The fork-holder is inserted in the palm of the hand, and consists of four elastic flaps which clasp the end of the fork handle. A certain amount of rotatory adjustment (by the other hand) is permitted to the wrist, so as to vary the presentation of the palm, in imitation of that performed by the ulna-radial motion.

PALMER gives a sinuous course to the flexor tendons of the fingers by means of sheaves, and opens the fingers by means of extensor tendons antagonizing the flexors by springs. The ball-and-socket wrist-joint is held together by cords.

In his forearm, the flexor and extensor tendons are similarly actuated, but the closing of the hand is effected by means of a strap to which the flexor tendons are attached. The strap is clamped in the flexed position when required.

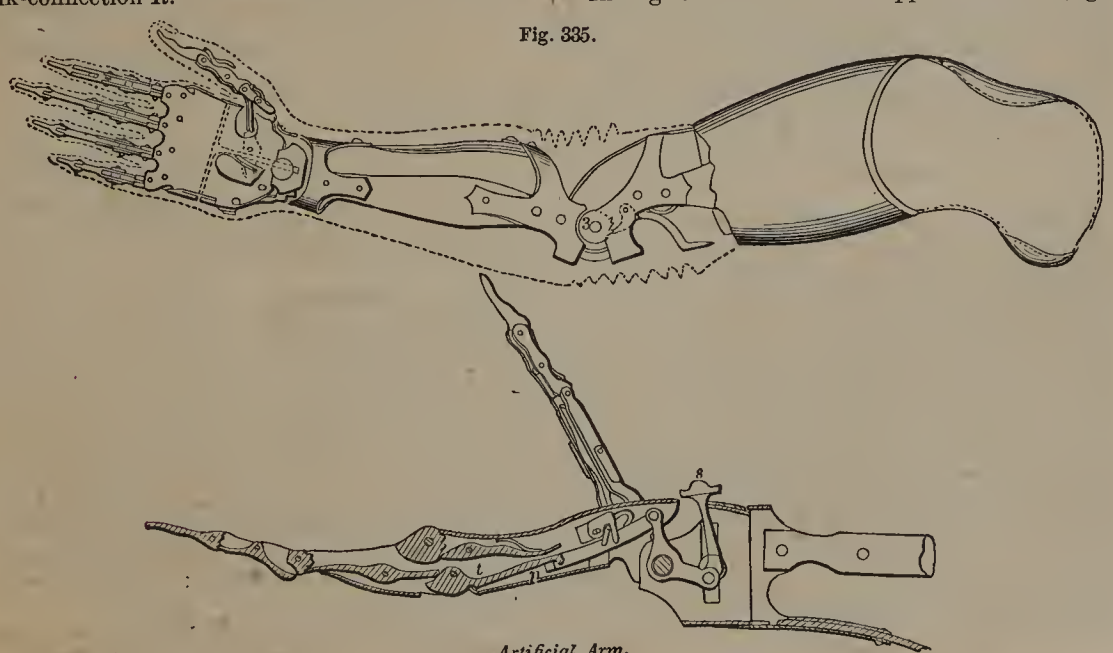
Fig. 334.



Artificial Arm.

In Fig. 334 the fore and upper arm are hinged

Fig. 335.



Artificial Arm.

together, and provided internally with a lock-plate to retain them in a flexed position when required. To release the forearm a projecting catch is touched, which disengages the catch-plate, allowing the arm to swing. To fasten the forearm flexed, it is swung forward, when the lock catches of itself. The hand is secured on the forearm, and it and the fingers are rigid in a grasping position. The thumb shown in the smaller figure has a constantly acting internal spring, and retains articles placed in the grasp between the thumb and fingers. The hand may be detached, and a hook substituted therefor.

In Fig. 335 each articulation has a ratchet and spring pawl attachment whereby any flexion imparted is maintained until freed by a means which trips the triggers. The forearm at the elbow-joint has a ratchet, and a spring pawl is pivoted on the upper-arm piece. By pressing on the back of the pawl, the latter is disengaged and the forearm freed. By the other means cited, the thumb and fingers are flexed so as to grasp an object, and are maintained in their bent positions by their respective ratchets and pawls. By pulling out the button *s*, the cross-bar *p* is driven up and overturns the rods *t*, which will bring the fingers back to their distended position.

In the above, the *hand* has necessarily been considered in connection with the arm which actuates it, and in some cases owing to its being associated with an arm of peculiar construction, although its own operative parts had no necessary connection with that specific arm. For some other varieties of hand structure, see HAND, ARTIFICIAL.

Ar'ma-ment. A term expressing collectively all the cannon and small-arms, with their equipments, belonging to a ship or fortification; frequently applied, in a more restricted sense, to the artillery alone.

The armament of ships and forts has undergone a very great change within the past thirty years. About 1840 the 32-pounder gun was most usually employed both on shore and shipboard, 24-pounders forming no inconsiderable proportion of the armament of our forts. 8-inch and even 10-inch guns and howitzers were, however, mounted to some extent in the more important seaboard fortifications.

The armament of a line-of-battle ship mounting eighty-four guns consisted of twenty-two 32-pounders of 57 cwt. and ten 8-inch shell-guns of 63 cwt. on each of the two gun-decks, and twenty 32-pounders of lighter weight on the spar-deck; that of a 50-gun frigate was similar, omitting the battery of one gun-deck. In 1857 a 40-gun steam frigate was armed with twenty-four 9-inch guns on the main-deck and fourteen 8-inch and two 10-inch pivot-guns on the spar-deck; 11-inch pivot-guns were also introduced as a part of the armament of steam sloops and smaller vessels.

Rifled or breech-loading ordnance was practically unknown. The commencement of our late civil war brought with it the era of 15-inch smooth-bores weighing 50,000 pounds, and at or shortly after its close 20-inch guns, weighing more than 100,000 lbs. and carrying a ball of 1,060 lbs., had been cast. The former of these classes now forms the usual armament of our monitors. Rifled guns of calibers up to 10 inches (as the Parrott 300-pounder) were also introduced, and this size has been exceeded in Europe, 30-ton Armstrong breech-loaders, carrying a projectile of 600 lbs. weight, being now in use in the English navy, while North Germany and other continental nations are little, if any, behind in this respect. In the United States service great reliance has been placed on the "smashing" qualities of round projectiles of large caliber fired from smooth-bore guns when employed against iron-clad vessels, while the impression of European artillerists is that they are comparatively inefficient in competition with elongated projectiles discharged from rifled guns; these are, accordingly, the only kind now employed abroad on first-class war vessels, and appear to have almost, if not entirely, superseded smooth-bores, with the exception of mortars in the armament of fortifications.

Ar'ma-ture. A piece of soft iron applied to a loadstone or connecting the poles of a horseshoe magnet.

In certain forms of electro-magnetic instruments a magnetized armature is employed, which may either be a permanent magnet of steel or an electro-magnet. The armature must have a polarization the opposite of that of the magnet and by its use the recoil-spring may be suppressed.

Arm File. A name from the German. A *hand* file.

Ar'mil. An ancient astronomical instrument. When composed of one ring placed in the plane of the equator for determining the time of the equinoxes, it is called an *equinoctial* armil. When of two or more rings, one in the plane of the meridian for observing the solstices, it is called a *solstitial* armil. — WHEWELL.

The *equinoctial armil* of the "Square Porch" of Alexandria is referred to by Hipparchus and Ptolemy. A *solstitial armil* is also described by Ptolemy (see Whewell, I. 201). These armils are divided into parts of sixths of degrees (10′). The reading was stated in parts of the circumference. Thus, Eratosthenes stated the interval between the tropics to be $\frac{1}{8}\frac{1}{8}$ of the circumference. Ptolemy used a part of a circle, a *quadrant*.

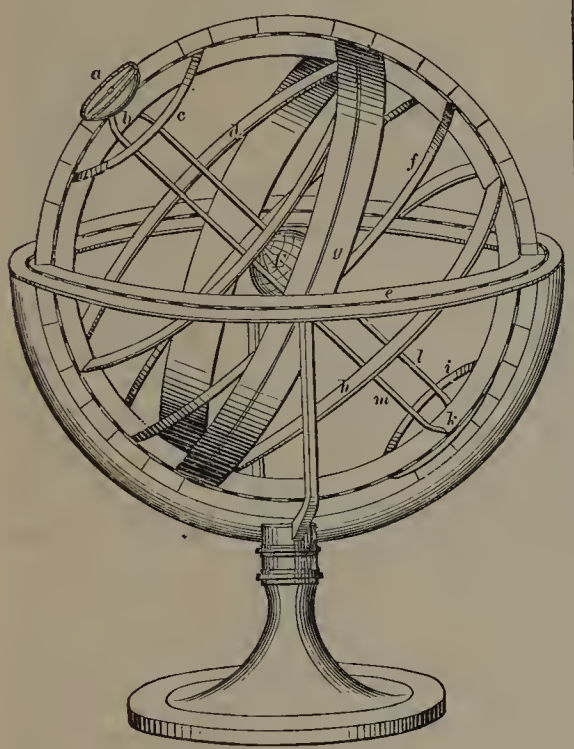
It is supposed that Eratosthenes suggested to Ptolemy Euergetes the construction of the large *armillæ*, or fixed circular instruments which were long in use in Alexandria. Eratosthenes of Cyrene was born B. C. 276, and left Athens at the invitation of P. Euergetes, who placed him over the library in Alexandria, where he remained till the time of P. Epiphanes about B. C. 196. He is celebrated for his attempt to measure the magnitude of the earth. He discovered the obliquity of the ecliptic, which he made to be 23° 51′ 20″. He ascertained that Syene in Upper Egypt (lat. 24° 10′ N.) was in the tropic, a vertical gnomon casting no shadow at noon on the day of the summer solstice, and thence determined its latitude to be equal to the obliquity of the ecliptic. Observations at Alexandria determined the zenith of that place to be distant $\frac{1}{5}\frac{1}{0}$ part of the circumference of the earth from Syene, the arc of the meridian between the two places being equal to 7° 12′, which was measured by the Ptolemies and found to be 500 stadia. This gives roughly 250,000 stadia for the circumference of the earth. The Olympic stadium was 202¾ yards. See ODOMETER.

Ar'mil-la-ry Sphere. An instrument to illustrate the motions of the heavenly bodies. It was invented by Eratosthenes about B. C. 255, and was employed till the time of Tycho Brahe, A. D. 1582. It was ordinarily made of brass, and disposed in such a manner that the greater and lesser circles of the sphere are seen in their natural position and motion. It was perhaps the principal agent in astronomical observations in the museum of Alexandria, which was founded by Ptolemy Soter, B. C. 298, and was plundered by Cyril A. D. 415, who probably thought the sphere was some heathenish machine for invoking the infernal gods.

It was used by Aristarchus, who first took the heliocentric view of the solar system; by Archime-

des, the grand master of mechanics, contemporaneously with the building of the great wall of China; by Eratosthenes, the originator of astronomical geography; by Hipparchus, the father of mathematical astronomy; and by Ptolemy, the astronomer, A. D. 150, whose system was accepted down to the time of Tycho Brahe, A. D. 1582, and until Copernicus, Kepler, and Galileo revived the true views of Aristarchus, the heliocentric theory promulgated nearly two thousand years before.

Fig. 336.



Armillary Sphere.

E. The earth.
a. Hour circle.
b. North pole of the heavens.
c. Arctic circle.
d. Tropic of Cancer.
e. Celestial horizon.
f. Celestial equator.
g. Ecliptic.
h. Tropic of Capricorn.
i. Antarctic circle.
k. South pole of the heavens.
l. Solstitial colure (summer).
m. Solstitial colure (winter).

The armillary sphere consists of a frame with a horizon on which are represented the 360°, the region of the heavens, the calendar, and the hight of the sun for every day in the year. Two notches in the horizontal circle, and corresponding to its north and south points, receive the fixed meridian, whose plane is perpendicular to, and center coincident with, that of the horizontal circle. Within this meridian the other circles, as well as the small terrestrial globe, may all be rotated together on the common axis of the heavens and earth. The meridian can be moved in its notches, still retaining its vertical plane, and in this manner the general axis may be placed at various angular distances with the horizon. The center of the small terrestrial globe is coincident with that of the general armillary sphere. The hour circle is fastened to the north pole of the fixed meridian, and has a movable index, which when fastened revolves with the axis. It is still used in demonstrating astronomical problems.

The armillary sphere of the Hindu astronomers is described in the Sanscrit treatise "Sûrya-siddhânta," translated by Rev. E. Burgess, and published in the Journal of the American Oriental Society, Vol. VI. pp. 141–498, New Haven, 1860. The instrument was illustrative of the positions and motions of the heavenly bodies, rather than for astronomical observations; in this respect differing from the Greek, Arab, and early European instruments.

Arm'ing. (*Nautical.*) A plug of tallow in the hollow at the bottom of a sounding lead, to bring up sand, minute shells, infusoriæ, etc., from the bottom.

Arm'ing-press. (*Bookbinding.*) A screw press having a platen heated by gas-jets, and serving to fix the gold-leaf upon the book-covers upon which it is impressed. See BLOCKING-PRESS.

Arm'let. A clasp or loop for confining the sleeve to the upper portion of the arm. Used to loop up the short sleeve of children's dresses.

A protecting sleeve of leather or metal, worn on the forearm, and used as a shield for the arm or as a covering for that portion of the coat-sleeve.

Ar'mo-rer's Gage. For verifying the dimensions of the various parts of small-arms are templets of various sizes and shapes, rings, and cylindrical or conical gages for interior dimensions. 200 are embraced in a complete set for the various arms made at the Government armory, of which about 78 are used for the rifle-musket alone.

Of these, the *caliber gage* measures the diameter of the bore.

The *dimension gages* show the length of the barrel and its diameter at various distances, the value in inches and parts being measured by the *caliper gage.*

Other gages measure the proper dimensions of the breech-screw and its thread, and those of the counterbore of the barrel which receives it; others, again, the form, dimensions, and position of the sights.

A separate gage is required for the lock-plate, and for each separate part of which the lock is composed; as the *mainspring gage, sear gage, bridle gage, tumbler gage, hammer gage,* etc.; also gages for the various dimensions of the stock, of the bayonet, and of each of the appendages which accompany the gun.

The number of 200, above given, might be swelled to several thousand, by including those required for inspecting the various carbines and pistols made by different parties for the United States government; all which were made so that the parts of the same kind might be interchanged.

Ar'mor, Per'son-al. Defensive clothing or covering for the body in battle.

Scale and chain armor were common among the old Egyptians (time of Rameses III.) and Assyrians, also among the Persians and Romans. Dr. Abbott's collection in New York contains the iron helmet and scale armor of Sheshonk, or Shishak, the king of Egypt who overthrew Rehoboam, seven years after the death of Solomon. The scales are the shape of the Egyptian shield round end downward, and some of them are marked with the cartouche of the king.

The Sarmatians wore scale armor of pieces of horn or horse-hoofs fastened to a linen doublet.

Goliath was armed with a coat of mail (1 Samuel xvii). It is frequently spoken of by Homer. Demetrius, son of Antigonus, had a coat of mail made of Cyprian adamant (perhaps steel). Cyprus was famous for its armor. The ancient Scythians had armor composed of horse's hoofs curiously strung and jointed together. Hengist the Saxon had scale

armor A. D. 449, and King John of England possessed a hauberk of rings set edgewise, 1200. The cavalry of Henry III. had coats of mail. Henry VII. had a steel cuirass, 1500. Since the introduction of fire-arms the use of armor has been gradually discontinued, and it is now confined to the heavy cavalry or cuirassiers of European armies. As worn at present, it generally consists of a helmet of brass strengthened with steel, and a cuirass composed of a front piece, or breast-plate, and a back piece strongly laced or buckled together. The success of the French cuirassiers in the famous cavalry combat at Eckmuhl, 1809, was in a large degree owing to their wearing complete cuirasses, while the Austrians were only provided with breast-plates.

For illustrations and descriptions see Frost's Pictorial Histories, and the Iconographic Encyclopædia.

Of ancient armor some remarkable examples are to be found in the tribolites of the Silurian age, "a family in whose nicely jointed shells the armorer of the Middle Ages might have found almost all the contrivances of his craft anticipated, with not a few, besides, which he had failed to discover. They were covered over, back and head, with the most exquisitely constructed plate-armor; but as their abdomens seem to have been soft and defenceless, they had the ability of coiling themselves round on the approach of danger, plate moving on plate with the nicest adjustment, till the rim of the armed tail rested on that of the armed head, and the creature presented the appearance of a ball defended at every point. In some genera, as in Calymene, the tail consisted of jointed segments till its termination; in others, as in Illænus, there was a great caudal shield, that in size and form corresponded to the shield which covered the head; the segments of Calymene, from the flexibility of their joints, fitted close to the cerebral rim; while the same effect was produced in the inflexible shields, caudal and cephalic, of Illænus, by their exact correspondence, and the flexibility of the connecting rings, which enabled them to fit together like two equal-sized cymbals brought into contact at every point by the hand." — HUGH MILLER.

Ar'mor-plat'ed Ves'sel. A vessel whose exposed portions are protected by iron plates. The plating reaches a certain distance below the water-line when in fighting trim. See ARMOR-PLATING.

Ar'mor-plates, Ham'mer-ing and Roll'ing. Armor-plates may be either hammered or rolled. When it is desired that the armor shall be of one thickness of stout plate of from four to six inches, hammered iron seems to be preferable on account of the increased tenacity conferred upon the plate by the closer interlacing and condensation by this process. Owing principally, however, to the greater rapidity with which rolled plates can be manufactured, and the facility with which they can be laid together and bolted so as to constitute armor of any required thickness, and the ease with which a damaged plate can be replaced, the rolling process has been more generally resorted to in this country. Hammered-iron plates are made from "blooms," which may be procured from the forge, or preferably made at the works where the plate is forged. Any description of good scrap wrought-iron will answer for this purpose, as it is soon converted into one homogeneous mass under the steam-hammer. The scraps are piled into "fagots" of convenient size, and placed in the furnace. After reaching a welding heat, they are taken from the furnace by tongs suspended from a chain, and laid upon an anvil under the steam-hammer. By the first blow of the hammer an iron rod, one end of which is held by a workman, is welded into the fagot for the purpose of turning and manipulating it while being hammered. A very few minutes' pounding by the heavy hammer suffices to bring the mass into the bloom shape, — a bar of homogeneous iron some four or five feet in length and six inches thick; when sufficiently hammered, the handle is cut off, and the bloom is ready to take its place in combination with others in the formation of a plate. In this operation a long and stout bar of round iron, flattened at one end, is used for supporting the pile, which is composed of several layers of blooms laid in tiers one upon the other transversely; these are placed in the furnace upon the flattened end of the above bar, which is suspended near its mid length from a crane, and is clasped by tongs or handles to enable the workmen to turn and move the mass as desired; when sufficiently heated for welding, which requires several hours, the pile is drawn from the furnace, swung round and placed upon the anvil by the crane assisted by the handles held by the workmen, and subjected to the action of the hammer.

When the blooms are thoroughly welded and the pile drawn down to about the required width and thickness of the plate, another pile of blooms is added, welded on to its end, and the operation thus continued until the desired length is attained. When this operation is completed, the plate is again heated and passed under the hammer, water being thrown upon it as it is advanced forward, which assists in removing scale and cleaning and smoothing the plate; these are then drilled to receiving the bolts for fastening them into position on the ship, and afterward bent to the required curve.

The operation of rolling the larger description of armor-plates involves a number of appliances not usual in ordinary rolling-mills. The mass of iron, being heated in the furnace, is drawn thence by chains attached to the steam-rollers and received by a wrought-iron car. The forceps being detached and the chains clear from the rolls, the car is advanced to the head of the incline, which it then traverses by its own weight, and lands the edge of the plate into the grip of the rotating rolls. The plate is received on the other side of the rolls by another wrought-iron truck. The rollers being set nearer to each other by about an inch, their motion is reversed, the plate landed into their grip, and carried through to the other side. This is repeated again and again, setting the rollers closer between each operation, until the required dimensions are obtained. Sand is thrown on the plate from time to time, and water, which detaches the scale of oxide. This is removed by scrapers. The plate, being then laid upon the floor, is subjected to the action of 15-ton rollers, which levels and smooths the surface. The dimensions here stated refer to the apparatus used in rolling a 15-inch armor-plate in England.

Ar'mor-plat'ing. The application of iron for this purpose is of very modern origin. Cast-iron plates had been proposed long before as a revetment or facing for fortifications; but this material was soon found unsuitable, on account of its brittleness, and consequent liability to be fractured by shot.

Iron armor was suggested in the United States in 1812, in France in 1821, and was experimented upon in England in 1827 at the suggestion of General Ford, who proposed to protect fortifications by wrought-iron bars.

Gregg's United States patent, March, 1814, was an iron-clad bomb-proof steam vessel, and will be noticed presently.

Captain. Thunderer. Glatton.

ARMOR-PLATED V

(*English and Amer*

PLATE IV.

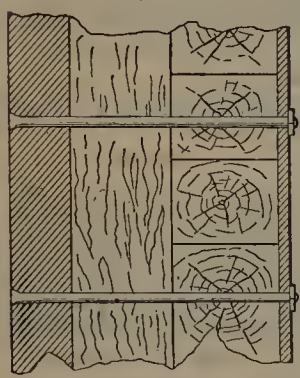
Monitors. Dunderberg. Monitor.

See page 150.

The first practical use of wrought-iron plates as a defense for the sides of vessels appears to have been made by the French during the Crimean war. These vessels, — floating batteries, as they were termed, — though they seem to have had sufficient sea-going qualities to enable them to navigate the Mediterranean and Black Sea, were of light draft and exposed very little surface above water; they rendered very efficient service, especially at the bombardment of Kinburn, in 1855, and their success probably led to the adoption by the French government of armor-plating on a much more extended scale; "La Gloire," launched in 1859 or 1860, having been the first large iron-plated ship afloat. Her armor consisted of 4½-inch rolled-iron plates, supported by a backing of wood some three feet in thickness.

England, with the determination not to be behind her Continental neighbor, commenced the construction of iron-clads immediately afterward. The most noted of those first built in England was the "Warrior," whose armor was of 4½-inch plates, backed by and bolted on to 18 inches of teak wood; the plating, however, merely covered the midship portion of the vessel for some 200 feet, leaving a large space both at the bow and stern of the vessel unprotected.

Fig. 337.



Section "Warrior's" Armor.

Another class of iron-clads in the British Navy, represented by the "Royal Oak," were wooden ships of the line, not originally intended for carrying armor, but which have been covered with 4½-inch iron plates bolted on to their wooden hull. In one respect they have the advantage of the "Warrior," their sides being completely mailed from stem to stern, as are those of "La Gloire." The "Minotaur," and others of her class, were originally constructed to receive plating. They are of very large size, about 6,650 tons, and are also completely protected, the plating extending throughout their entire length, and to a depth of several feet below the water-line; it is similar to that of the "Warrior," from 4½ to 5½ inches thick, having, however, a wooden backing of but 9 inches, which is said to be, and no doubt is, too thin to insure the great rigidity required.

Fig. 338.

"Hercules."

The armor adopted for the "Hercules," which was another typical form of English iron-plating, consists of an outer plating of rolled iron 8 inches thick, inside of which is 12 inches of wood, 1½ inches of iron, and 26 inches of wood, in the order named, and an interior iron lining.

Mr. Chalmers's system, for which he claims very superior efficiency and strength, is represented in the annexed figure; it is composed of alternate layers of iron and wood, the outer iron plating being strengthened by horizontal plates interposed between the beams of the outer layer of wood.

Fig. 339.

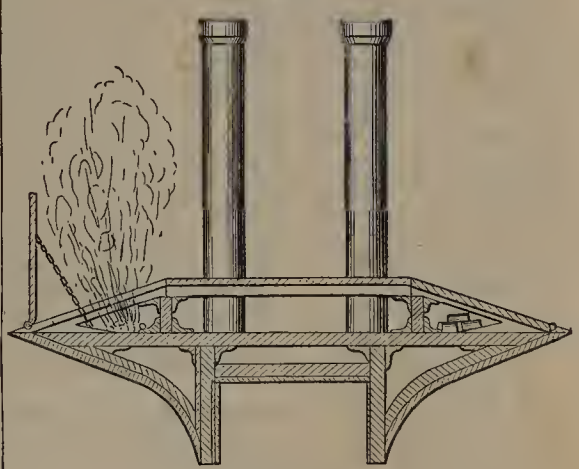
Chalmers's.

This armor has been severely tested in England, and is reported to have given very good results.

It is understood that the "Palisser" bolt, in which the shank is reduced to the same diameter as that of the smallest part of the thread, is now used for fastening armor-plates in the British navy.

The subject received very early attention in this country, and as early as March, 1814, a "Ball-proof Vessel" was patented by Thomas Gregg, of Fayette Co., Pennsylvania. The design embraced a flat upper deck, from which the sides and ends sloped outwardly to the water-line, where the upper part of the vessel was very broad, overhanging the submerged portion and protecting the rudder and means of propulsion. The gun-deck was nearly level with the water-line, and ports were cut in the sloping sides. The external appearance of this

Fig. 340.



Gregg's Ball-proof Vessel.

floating battery seems to have been very similar to that of the confederate "Virginia," formerly the "Merrimac," or some of our Western iron-clads. Copper or iron was proposed as a covering for the exposed portion. It does not appear that a vessel was ever actually constructed on Gregg's plan, but the invention is interesting as embodying some of the features which were afterwards adopted by both North and South during the emergencies of our late war, and as showing that only some seven years after the first successful application of steam as a motive-power for vessels, it was proposed to employ it as a means of propulsion for iron-clad floating batteries.

In 1842 the late R. L. Stevens commenced at New York the construction of an iron-clad war-vessel, under an agreement with the government, which seems to have never been completed.

This vessel, it is understood, was intended for speed, her lines being very sharp. Her dimensions have been stated as follows: —

Extreme length . .	420 feet.	
Beam	52 "	
Depth from fighting-deck	28 "	
Draft with coal and stores	20 "	6 inches.
Fighting-draft . . .	22 "	6 "

She is provided with compartments into which water is admitted upon going into action, so as to sink her two feet deeper in the water, thus leaving a lesser exposed surface. These compartments may be rapidly emptied by steam-pumps. The side armor extends outside of the hull from stem to stern to a distance of four feet below the line of fighting draft, and is plated with 3½-inch iron. The armor of the casemate, which is sloping and has a shot-proof deck, is composed of 6¾-inch plating backed by 14 inches of locust timber, in which are imbedded 6-inch wrought-iron beams at distances of two feet from each other. The upper deck is of 1½-inch iron plates resting on 6-inch wrought-iron girders, filled in with timber and lined with ½-inch iron plate. The guns are to be used *en barbette* upon the top of the casemate, and are to be loaded from below, by machinery, through holes in the deck; they are pointed from within, and by means of a graduated index within the casemate each gun may be brought to bear simultaneously on the same object.

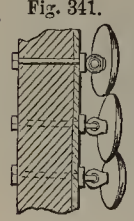
Captain Ericsson designed the Monitor class of vessels in 1854, though the idea seems to have lain dormant till the times were propitious. The "Monitor" attacked the "Merrimac" March 9, 1862, and, on the 11th of May following, the latter committed suicide. The revolving turret was invented by T. R. Timby, and was patented by him in 1862. Captain Coles introduced a modification into the British navy, and was lost when the ill-fated double-turreted "Captain" foundered off Cape Finisterre, July, 1870. The "Captain" had two large turrets placed amidships, in each of which were mounted two 25-ton rifled guns, throwing solid elongated projectiles of 600 pounds, or shells of proportionate weight. In the forecastle and poop were two or three guns of smaller caliber. The thickness of her plating varied from six to ten inches. She was full-rigged, had two independent screws, engines of extraordinary power, steering apparatus of curious perfection, and a picked crew of 500 men.

The original "Monitor" foundered off Cape Hatteras with all on board.

There are now 54 iron-clad monitors in the United States service. The plating of the deck and overhanging portion of the hull usually consists of five 1-inch iron plates, backed by and bolted on to a wooden backing some three or more feet in thickness. The revolving turret is composed of eleven similar plates, firmly bolted together, and so arranged as to break joints.

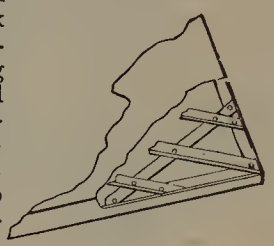
As might naturally be supposed, the late war was fertile in the production of devices for the protection of war vessels, displaying more or less ingenuity and adaptability to that object. In the first and most numerous class of these, solidity and strength, derived from the arrangement of the plates and the manner of fastening and backing them, were principally taken into consideration; while in the second it was proposed to deaden the force of a ball striking the armor by giving the latter a considerable degree of elasticity or resiliency, allowing it to yield and afterward return to its normal position. Some examples of each of these classes will be given, as illustrating the different modes proposed in order to arrive at the same result. These are arranged according to the dates of the patents. Among the first was that of F. COMTESSE, April 22, 1861, who proposed to employ convex rounded shields, partially overlapping each other, attached to the sides of the vessel by loops and eye-bolts, for the purpose of causing the ball to glance off upon striking.

Fig. 341.



Comtesse's Armor.

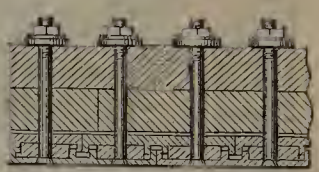
Fig. 342.



WARDEN'S patent, February 25, 1862, embraces a wrought-iron lattice framing, in and upon which an iron body is cast, so that, the latter being fractured, the pieces would still maintain their places, and protect, or partially so, the side of the ship.

Warden's Armor-Plating.

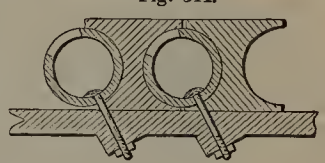
Fig. 343.

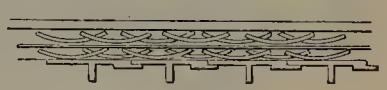


Jones's Armor-Plating.

JONES'S Defensive Armor for Land and Water Batteries, April 15, 1862. In this invention the armor-plates have edge and intermediate flanges, and are placed in two tiers having intermediate cushions between them; they rest against foundation-cushions, the whole being bolted together and to the casemate or side of the vessel by bolts, which are provided with elastic washer-cushions.

Fig. 344.

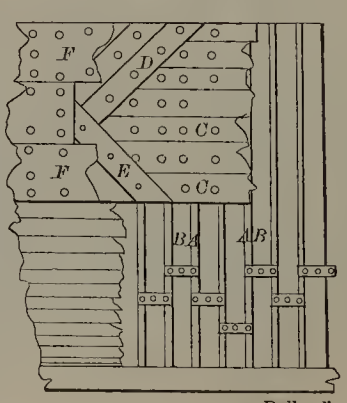


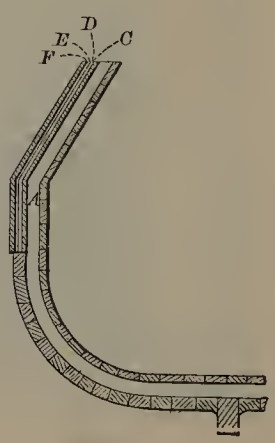


Callender and Northrup's Armor.

CALLENDER AND NORTH-

Fig. 345



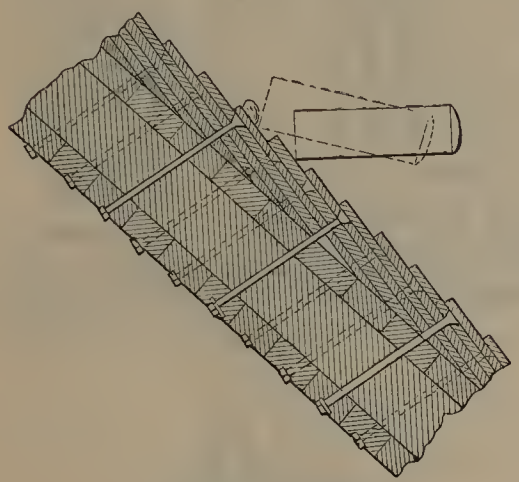


Bullard's Armor.

RUP's Defensive Armor, May 27, 1862, is composed of ribbed plates which are fastened to interior concave stringers by bolts passing through the stringers and into metallic tubes between them; each plate has a lap at its edge to fit the corresponding edge of the next plate, to which it is riveted. The nuts are on the outside.

BALLARD's armor, June 24, 1862, consists of a series of inner iron ribs A A, with interposed wooden frames B B, longitudinal covering bars or plates C C, diagonal bars or plates D E, and outer covering plates F F.

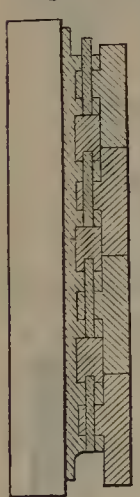
Fig. 346.



Hotchkiss's Armor.

HOTCHKISS's "Metallic Defensive Armor" for vessels and fortifications is formed by a series of plates, in which the lower ones overlap the higher, so that when any one of them is struck by a projectile, the projecting edge may become detached, glancing the shot on to the next plate, by which it is further deflected and prevented from penetrating the armor. The cut represents the action of a cylindrical bolt whose edge has impinged upon one of the lapping plates; the dotted lines show the bolt in a subsequent position, in contact with the piece of armor-plate which it has removed, and glancing upon the successive plates.

Fig. 347.



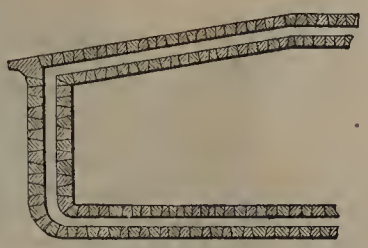
Wood's Armor.

WOOD's armor, September 23, 1862, comprises sets of inner and outer plates, the former secured to the vessel by bolts whose heads are covered by the latter, each plate in the one set having a rib which fits between ribs on a plate of the other set, the two plates being connected together by pins passing vertically through the ribs. Longitudinal spaces are left at intervals between the inner and outer plates for the introduction of wood or an equivalent material.

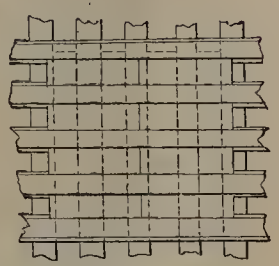
BABBITT's armor-plating, January 13, 1863, for ships or batteries, is composed of wedge-shaped bars laid crosswise to two other sets of bars, the whole being dovetailed together and filled in with cast metal.

MONTGOMERY's armor, February 10, 1863, depends much upon its resiliency to resist the impact of projectiles. The outer plates are notched into each other, and fastened together and to a corrugated plate by a rod. This corrugated plate rests against the outer casing, between which and the inner casing are cylinders of vulcanized rubber placed perpendicularly to the casings, the whole being bolted together.

Fig. 348.

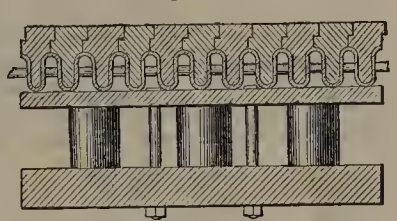


BRADY's method of "Affixing defensive Armor-Plates," March 3, 1863, is by attaching them edgewise to the object to be protected, and securing them by means of bolts, whose ends pass into cavities in the inner edges of the plates, and are made fast by being enlarged therein, or by being intersected by transverse apertures through which pins or keys may be passed.



Babbitt's Armor-Plating.

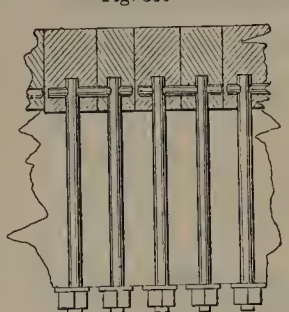
Fig 349.



Montgomery's Armor.

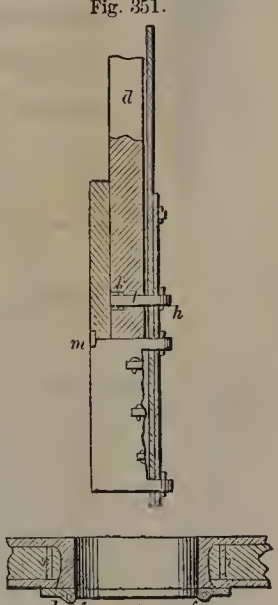
In WAPPICH's system, March 3, 1863, the outer plates have projections passing through the hull and interior plating, where they are keyed; each outer plate has also projections or lugs *k*, entering the casing *d* to a certain distance, and receiving

Fig. 350



Brady's Armor-Plating.

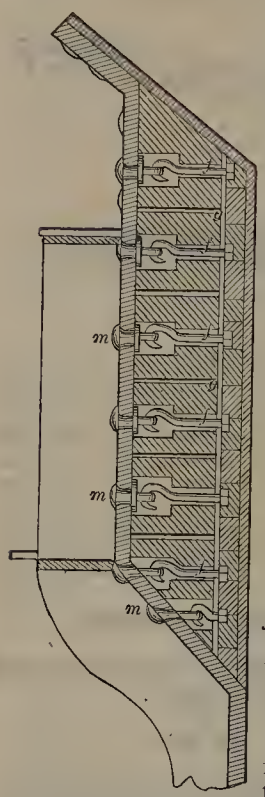
Fig. 351.



Wappich's Armor.

the bolts *l*, which are keyed to the interior plate: it has also notched flanges, or bent ends, passing into the casing; these are employed to bind the ends of the plates together, and increase the stability of the armor. The outer adjoining edges of the plates are grooved for the insertion of india-rubber strips, as at *m*, for making the joints water-tight. The port-holes are strengthened by iron

Fig. 352.



Tufts's Armor.

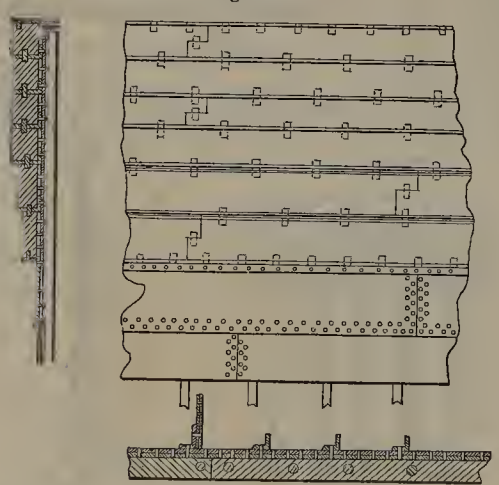
plates *o*, extending around their edges, and also by an encircling frame or ring *r*, between the inner and outer plating. Each plate may be so arranged as to be pushed out, upon removing the keys *h*, and others substituted. This system of plating is designed for circular turrets, as well as for plain or slightly curved surfaces.

TUFTS'S Construction and Defence of War Vessels, March 24, 1863. The sides of the vessel are recessed by bending inward the frame and the plating thereon, thus maintaining the symmetry of the outward form.

Recesses are made in the sides, in which the fixtures *m m* are secured, having eyes into which screw-bolts *f f* are hooked. These screw-bolts pass through the casing to the outside of the straps *g*, where they screw into nuts.

EADS'S Defensive Armor for Marine and other Batteries, July 14, 1863, consists of inner angle-irons, the flanges of which pass between the horizontal layers of armor-plates. Dowel-pins, inserted in holes in the flanges, enter the

Fig. 353.



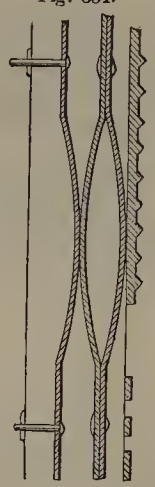
Eads's Armor.

layers of armor-plating above and below them, thus binding the whole together. The plates are so arranged as to break joints.

TWINING'S "Means of Cheeking and Resisting Missiles," July 28, 1863, embraces an arrangement of successive plates or layers with successive intervals between, and with lugs, angle-irons, or projections, when necessary; the mode of constructing the successive layers and spaces between is by bending forward and back a single plate, or several plates in layers, from the outside to the inside, the plates being bolted together occasionally at their contacting portions.

The arrangement of DIMPFEL'S armor, Aug. 4, 1863, will be readily understood by reference to the cut. The ends of one series of plates are let into grooves of a transverse set of T-iron plates, which

Fig. 354.

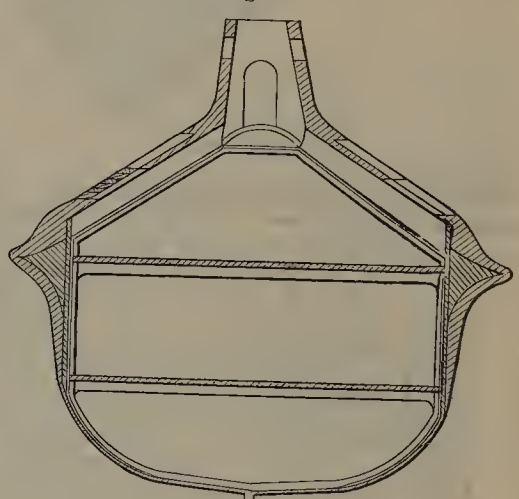


Twining's Armor.

Fig. 355.

Dimpfel's Armor.

Fig. 356.

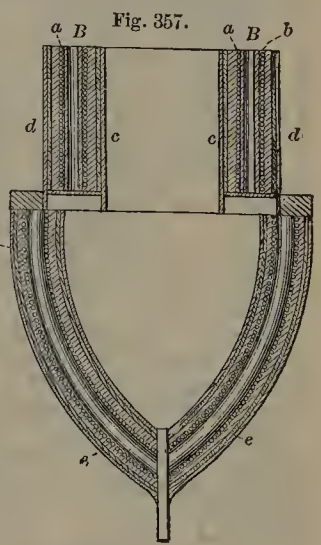


Caudwell's Armor.

are bolted to the backing. It is intended for application to either land or marine batteries.

CAUDWELL'S Construction of Ships of War. This invention was patented in England April 10, 1863; in the United States, January 19, 1864. The design embraces a corrugated iron-plated roof with port-holes in the corrugations; the port-shutters are composed of a number of separate plates of iron or steel one above another, and fit into grooves in the edges of the armor-plates. Around the vessel, just above the water-line, is a

Fig. 357.



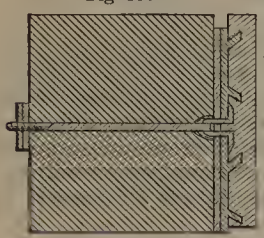
Collins's Armor.

projecting lip, to which india-rubber, or other similar material, may be attached.

Collins's Armor for Ships and Fortifications, April 19, 1864, consists of a framing of wrought-iron tubular ribs *B B*, with external coils of steel wire *a a*, and surrounding casings of india-rubber *b b*. Corrugated plates *e e* confine the tubes together, and serve as attachments for the inner and outer skins *c d*.

Carpenter's Ship's Armor, May 23, 1865. In this device the middle plates, of steel or wrought-iron, have dovetailed projections fitting into corresponding grooves in their outer facings, which, as well as the inner backing-plates, are of chilled cast-iron. Staples pass through the inner and middle plates and into the outer one; the loop of each staple is let into a recess in the side of the vessel, and is caught by a bolt which passes through the side and is secured in the interior.

Fig. 358.



Carpenter's Armor.

The following statement from the "London Times" contains the dimensions of a number of English iron-clads, with the thickness of their armor, etc.

Names.	Tonnage.	Horse-Power.	Length.	Beam.	Protected Guns designed for.	Thickness of Armor.	Thickness of Backing.
Achilles	6,221	1,250	380	58	26	4½	18
Black Prince	6,109	1,850	380	58	26	4½	18
Warrior	6,109	1,250	380	58	26	4½	18
Agincourt	6,621	1,350	400	59	36	5½	10
Minotaur	6,621	1,350	400	59	36	5½	10
Northumberland	6,621	1,350	400	59	36	5½	10
Hector	4,089	800	280	56	32	4½	18
Valiant	4,063	800	280	56	32	4½	18
Defence	3,720	600	280	54	16	4½	18
Resistance	3,710	600	280	54	16	4½	18
Caledonia	4,125	1,000	273	59	32	4½	Wood ship, side 29½ in.
Ocean	4,047	1,000	273	58	32	4½	" 29½ "
Prince Consort	4,045	1,000	273	58	32	4½	" 29½ "
Royal Alfred	4,068	800	273	58	32	4½, 6	" 29½ "
Royal Oak	4,056	800	273	58	32	4½	" 29½ "
Lord Clyde	4,067	1,000	280	59	34	4½, 5, 6	" 31½ "
Lord Warden	4,067	1,000	280	59	34	4½, 5½, 6	" 31½ "
Zealous	3 716	800	252	59	16	4½	" 30½ "
Bellerophon	4,246	1,000	300	56	12	6	10
Pallas	2,372	600	225	50	5	4½	Wood ship, side 22 in.
Favorite	2,094	400	225	47	8	4½	" 23 "
Research	1,253	200	195	38	4	4½	" 19 "
Enterprise	993	160	190	36	4	4	" 19½ "
Viper	737	1 0	160	32	2	4½	10
Vixen	754	160	160	32	2	4½	10
Water Witch	777	167	162	32	6	4½	10
Prince Albert	2,529	500	240	48	6	4½	18
Royal Sovercign	3,765	800	240	62	5	5½	Wood ship, side 36 in.
Scorpion	1,857	350	220	42	4	3, 4½	9
Wivern	1,857	350	220	42	4	3, 4½	9

"The British naval authorities have lately tried a practical, if expensive, experiment by anchoring their biggest and newest iron-clad, the "Glatton," in Portland harbor, and detailing another ship to make her turret a target for 600-pound projectiles. The Admiralty is probably satisfied with the trial, for although the turret was pretty badly damaged it was not disabled. The experiments will be continued in the hope of finding a system of iron-plating which will resist any possible projectile, and a projectile which will knock to pieces any possible system of iron-plating." — *English Paper.*

This is of a piece with the old problem, which modern slang would call a conundrum: "When an irresistible body comes in contact with an immovable object, what is the result?"

Ar/mor, Sub-ma-rine'. Submarine armor may be held to include all the devices to be attached to the person by which one is enabled to descend in the water, be protected from extreme pressure while submerged, be furnished with vital air and with means for signaling the persons above and for assisting the ascent to the surface when necessary. These devices have been used in connection with the diving-bells, but the latter is not a necessary auxiliary. In the article on the diving-bell some instances of submarine armor are given, but only as incidentals.

Submarine armor has not as clear claims to antiquity as the diving-bell, if we accept the accounts of Aristotle and Jerome. The earliest distinct account of the diving-bell in Europe is probably that of John Taisnier, quoted in Schott's *Technica Curiosa*, Nuremberg, 1664, and giving a history of the descent of two Greeks in a diving-bell, "in a very large kettle, suspended by rope, mouth downward"; which was in 1538, at Toledo, in Spain, and in the presence of the Emperor Charles V.

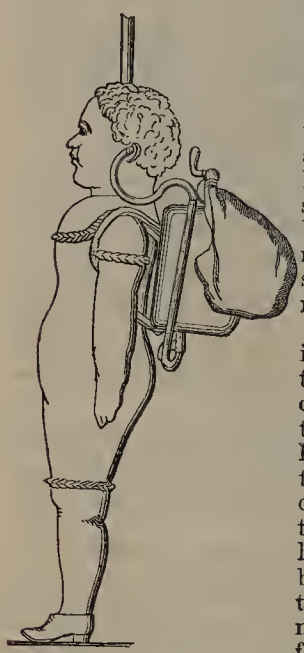
Beckman cites a print in editions of Vegetius on War, dated in 1511 and 1532, in which the diver is represented in a cap, from which rises a long leather pipe, terminating in an opening which floats above the surface of the water.

Dr. Halley, about 1717, made a number of improvements in the diving-bell, and among them a leather cap for the head of the diver, with windows in front for the eyes. This helmet was used by the diver when he left the bell, from which he received a supply of air through a flexible tube.

The essential parts of submarine armor consist of a helmet and a protection for the body. These are rendered necessary by the great pressure of the water even at moderate depths. For instance, at a depth little exceeding five fathoms (30 feet), this pressure amounts, including that of the superincumbent atmosphere, to about 29 pounds to the square inch, being an excess of some 14.7 pounds over that due to the atmosphere alone. For depths not exceeding 15 or 20 feet, armor for the body is not perhaps absolutely essential, though very desirable if the diver is required to remain a considerable time under water; this part of the apparatus may be constructed of leather, vulcanized rubber, or gutta percha, or of metal. The helmet is almost necessarily made of metal. It has glass windows to enable the diver to see, and two tubes, — one for supplying him with fresh atmospheric air from the surface, and the other for the eduction of the exhaled air. Weights are attached to the body of the diver or to the armor, if the latter is not sufficiently heavy of itself, to enable him to exert his full power under water; the human body being very nearly of the same specific gravity as that fluid. A line is attached to the apparatus, by which the operator is lowered to any given depth, or hauled to the surface by the assistants, and by which he can signal to them when necessary; for this purpose, however, another line is usually employed. Many different constructions have been proposed and executed. One of the best of the earlier forms was that of M. Klingert of Breslau, 1798, in which the helmet was made of strong tin, and the jacket and drawers of leather. Inhalation was made through a tube embraced by the lips of the diver, who, by the expansion of his chest at each inspiration, forced out of the helmet into another tube leading to the surface a quantity of previously exhaled air precisely equal to the fresh

air taken into the lungs. In some of the older forms the helmet itself was made large enough to hold a quantity of air sufficient to supply the diver for a considerable length of time, differing little, in fact, from the diving-bell. The apparatus of Mr. Rowe, 1753, consisted essentially of a copper tube large enough to contain the body of the diver and a limited supply of air which could be renewed from time to time by a bellows or force-pump, and having windows and water-tight holes for the arms. These cases have, however, been completely superseded by the diving-bell, and it by the more modern forms of armor, some of which will be mentioned. See DIVING.

Fig. 359.

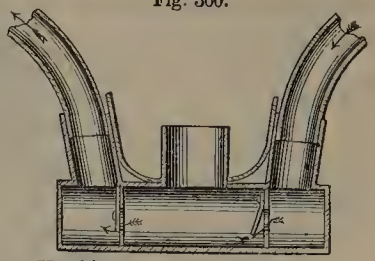


Diving Apparatus.

Fig. 359 shows a figure in a diving-dress, attached to which is a reservoir of compressed air sufficient to last the diver several hours. It is strapped to the dress, and communicates with the interior of the latter by a pipe which has a faucet. Expansible bags are attached to the shoulders, which are made buoyant by inflation from the compressed-air reservoir when required. The air-knapsack is weighted so as to enable the diver to sink to his work. The air-tube enters the mask at a point over the ear. The artist has made rather a close fit of the dress and mask, and the effect is rather too cherubic.

In Fig. 360 is shown a respirator designed to be attached to the helmet of the diver whereby air is supplied from a force-pump in the vessel which floats on the surface of the water. It has an induction and an eduction valve, which both open in the same direction, giving way respectively to the blast of fresh air and to the force of the exhaled breath. While the breath is being inspired by the diver the induction-valve is open to admit fresh air, and when expiration occurs, the induction-valve is closed, and the air passes out by the eduction-valve and the flexible tube, which latter reaches to the surface of the water.

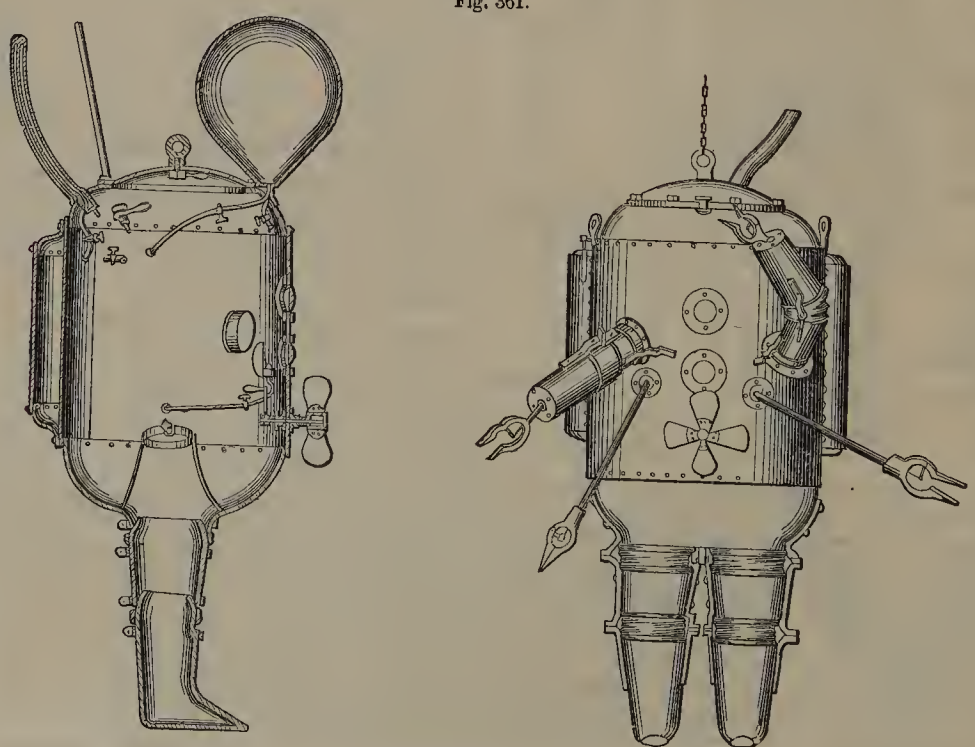
Fig. 360.



Hawkins's Mouthpiece for Diving Apparatus.

In Fig. 361 the diver is completely incased in the armor, which has flexible jointed limbs occupied by the legs and arms of the occupant, and enabling him to move from place to place and grasp the objects of his search or perform his other duty in the premises. The joints of the limb-casings have articulations corresponding to those of the person, and are flexed and extended by the natural motions of the diver. The prosthetic hands, which are attached to the ends of the tubular arm-casings, consist of tongs or nippers, operated by rods, which are moved by the natural hands inside. The body and head of the person occupy the chamber, which is large enough to permit free motion, and the chamber is attached to the person by bands, and a girdle about the loins. An exterior reservoir, partially encircling the chamber, contains compressed air, which is admitted to the chamber by a faucet, as the air may become vitiated by breathing. The opening of another faucet permits the vitiated air to escape through the tube which leads to the surface of the water. If the

Fig. 361.



Philips's Submarine Armor.

operator wish to ascend without assistance, he turns another faucet, which permits air to pass from the chamber into a collapsed bag attached to the top of the apparatus. As the bag becomes inflated, it displaces water and renders the whole apparatus buoyant. To descend again, he closes the cock leading to the balloon, and opens another which allows the air to escape from the balloon, which is collapsed by the pressure of the water. The compressed air is intended to form a supply for the trip, the connection with the surface consisting of a lifting and lowering rope and the eduction air-pipe.

Other armor for submarine explorations consists merely of helmets which have the necessary windows to allow the diver to see his work, and are provided with induction and eduction tubes to furnish the operator with a supply of vital air and carry off that which is vitiated.

Some exploring apparatus are adapted for making observations without descending. These consist of tubes, telescopic or otherwise, the lower end being brought into near proximity to the object; and in one case — Knight's English Patent, about 1847 — a second tube was provided, down which was projected light from a lamp or the reflected light of the sun, so as to illuminate the object whose character or position it was desired to ascertain.

In 1839, Thornthwaite (England) adopted a waist-belt of india-rubber cloth, to which was connected a small, strong copper vessel charged with highly compressed air. The belt is put on in a collapsed state, and the diver descends; but when he wishes to rise, by a valve he allows the compressed air to fill the belt, which increases his levity and assists his ascent.

The armor used by Mr. Dean in 1834, when he descended to the wreck of the Royal George (sunk off Spithead, August 28, 1782), was composed of india-rubber, made perfectly water-tight, and having a metallic helmet which rested on the shoulders and admitted free motion of the head. Three glass windows admitted light and allowed the diver to examine the remains of the ship. A flexible tube was connected to an air-pump above, and admitted air to the helmet. A sinking-weight of 90 pounds was attached to his person.

A race in submarine armor took place in Boston harbor on the 4th of July, 1868. The course was 2,100 feet, reaching from Long Wharf to the Cunard Docks on the East Boston side. Each diver had a submerged direction-line, and each arrived safely, being accompanied by his boat with its usual air-pump rigging. The time made was 17, 18½, and 21 minutes respectively. Each received a prize.

Ar-mo-zine'. (*Fabric.*) A thin plain silk, generally black, and used for clerical robes.

Arms. The club was the first offensive weapon. By knots and points it became a mace; an edge and a pole converted it to a battle-axe. It was adapted for thrusting by giving it a point, and became a pike or spear; and when adapted to be thrown became a dart or javelin, which might be recovered by a line, as among the Moors. Shortened and pointed, it became a dagger or poniard, and by receiving an edge became a sword, scimeter, or similar weapon. Pointed, and associated with a motor to propel it, we see the arrow and its bow, which is, critically considered, a really beautiful invention. See ARCHERY.

"The first weapons of mankind were the hands, nails, and teeth; also stones and branches of trees, the fragments of the woods; then flame and fire were used, as soon as they were known; and lastly was discovered the strength of iron and brass. But the use of brass was known earlier than that of iron, inasmuch as its substance is more easy to work, and its abundance greater." — LUCRETIUS; d. 51 B. C. *æt.* 44.

History commences after the invention of the bow and arrow, and the Australian race seems to have diverged from the parent stock before its introduction, as they, and they only, do not possess it. They have a curious analogue, however, in their flexible spears, which are bent, when adjusted for throwing, so that their reaction in straightening may increase the force of the projection. The peculiar course of their flight when they did not straighten perfectly may have suggested to them the very unique weapon, the boomerang, which was imported into England as a curiosity perhaps 30 years ago.

During the historic period we find the most ancient weapon noted in the Bible is the sword. It was the "instrument of violence," as Jacob called it, wherewith Simeon and Levi slaughtered the Shechemites (Genesis xxxiv. 25).

Phineas, the grandson of Aaron, carried a javelin. Ehud had a short dagger (Judges iii. 16). David declined Saul's sword, and used a sling, but afterward took the sword of Goliath. Many centuries before, all these weapons had been used in China, India, Assyria, and Egypt.

Pliny ascribes the invention of the sling to the Phœnicians. The Balearic Islanders were celebrated for their expertness in its use.

Slings and bows were employed by all the nations of antiquity, but among those who attained the highest military reputation, as the Greeks and Romans, were looked upon merely as auxiliary weapons, and the soldiers who used them were considered as an inferior class. The heavy-armed soldiers, who composed the strength of their armies, were armed with the spear and sword. The former, as used by the Greeks, was some 16 or even 18 feet in length, and enabled them to form a line of battle 16 men deep, — a solid mass capable of withstanding the most violent shocks, or of breaking the firmest ranks of any enemy who was not armed and disciplined like themselves; it was, however, deficient in mobility and activity. The Romans, on the contrary, preferred an order of formation and weapons which admitted of greater activity and allowed more scope to the efforts of the individual soldier. Besides a lighter spear, their principal weapon was the *pilum*, a short and massive javelin with a triangular iron head, which was darted by hand when within a few paces of their opponents, after which they drew their swords and advanced for close conflict. The Roman foot-soldier's sword was a short, two-edged weapon, greatly resembling the foot-artillery sword formerly used in the United States Army, and was adapted for either cutting or thrusting, though the soldier was instructed to prefer the latter as more effective and permitting him to preserve a better guard of his own person.

The formation of the legion was in eight ranks, and a distance of three feet was preserved between each file, as well as each rank, thus allowing ample room for the maximum effort of each separate man.

The offensive arms of the cavalry were a javelin and a long broadsword.

Cavalry does not seem to have performed such an important part among the Greeks and Romans as it did among the more Eastern nations, as the Parthians, whose mounted archers, on more than one occasion, defeated and almost annihilated the legions of Rome.

No important change in arms, except the introduction of the cross-bow, seems to have been made until the introduction of gunpowder; though the charac-

ter of the forces employed underwent a complete revolution. As Europe settled down into the gloom of the Middle Ages, disciplined armies became unknown, and the barbarous nations of the North who had overrun it, in the course of time becoming converted into peaceful tillers of the soil, had lost their former military habits, and in times of war degenerated into little better than camp followers.

Cavalry, including the knights and men-at-arms by whom they were attended, constituted almost the entire strength of an army, and being nearly invulnerable to the ordinary weapons used by the footmen of that day, such as pikes and bills, were capable of putting to flight or slaughtering with impunity many times their own number of the latter, who were in general destitute of armor of any kind. The introduction of fire-arms has gradually effected an entire change in the composition and discipline of modern armies, and though the lance and sword or saber are still employed, they are used merely as auxiliaries. See ARTILLERY, FIRE-ARMS, PROJECTILES, etc. For a list of arms of various kinds, cutting, missile, etc., see WEAPONS.

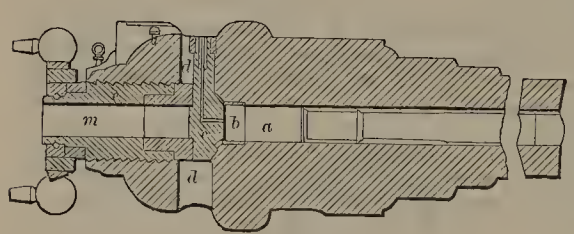
"Ships' arms are cannons, carronade, mortars, howitzers, muskets, pistols, tomahawks, cutlasses, bayonets, and boarding-pikes." — ADMIRAL SMYTH.

Arm'-saw. Another name for the hand-saw.

Arm'strong Gun. A description of ordnance adopted in the English artillery for all field-guns and many of larger caliber.

It is built up of different parts, so disposed as to bring the metal into the most favorable position for the strain to which it is to be exposed. See CANNON.

Fig. 362.



Armstrong Gun.

The illustration does not show the mode of *building up* the gun, but illustrates the mode of breech-loading. The inner portion of the barrel is made of coiled iron or steel, welded; that mode of constructing being adopted to avail the tensile strength of the metal in resisting the bursting force of the discharge. The mode of reïnforcing differs somewhat in the different calibers and styles of the arm, but consists, generally speaking, of a number of reïnforce bands of superior strength and thickness, over and in the vicinity of the charge-chamber and the parts weakened by the transverse cavity in which the breech-block is slipped.

a is the charge-chamber.

b the gas-check.

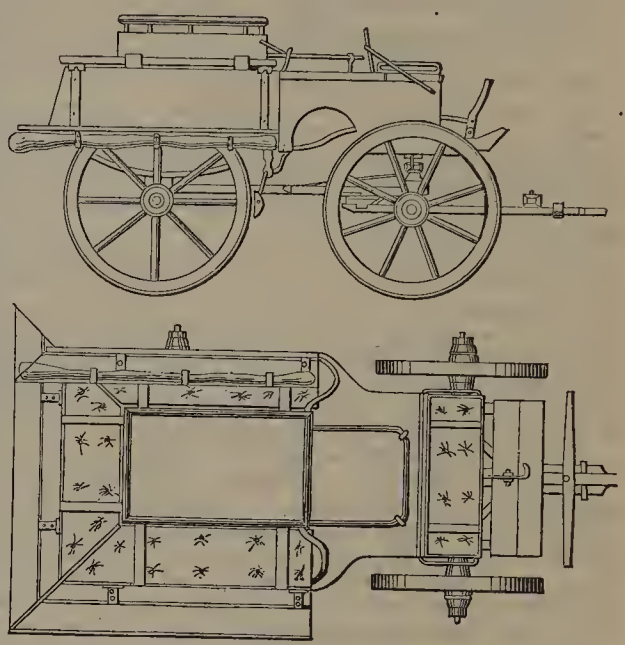
c is the breech-block which slides in a transverse slot *d*. The breech-block is traversed by the vent.

e is a breech-screw having an axial aperture *m*, through which the charge is introduced from the rear, when the breech-block *c* is withdrawn. After the charge is inserted in the chamber *a*, the block *c* is replaced, and the breech-screw *e* is screwed up, forcing a projection on the anterior face of the breech-block into the conical seat at the rear of the bore, and tightening the gas-check *b* in its seat, to prevent any escape of gas rearwardly.

Ar'mure. (*Fabric.*) A lady's dress-goods, having a cotton chain and woolen filling, twilled.

Ar'my Wag'on. A wagon designed for the use of foot-soldiers on the plains, and so constructed

Fig. 363.



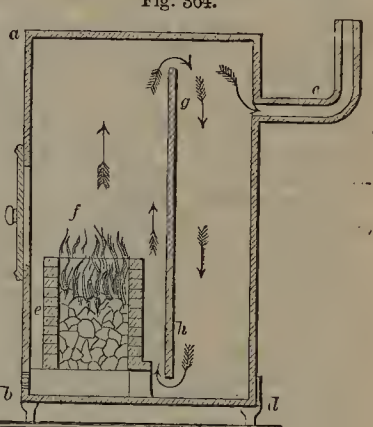
Army Wagon.

that the men can quickly jump off the seats when attacked, and spring back again at once. The term is also applied to wagons for stores and ammunition.

Ar'nott's Stove. The original form of Dr. Arnott's stove is shown in Fig. 364, and perhaps illustrates its peculiar principle better than do the subsequent modifications.

a b d represent a box of sheet-iron, divided by the partition *g h* into two chambers, communicating freely at the top and bottom; *e* is the fire-box, formed of iron, lined with fire-brick and resting on a close ash-pit with a door at *b*, near which is a valved opening by which air enters to feed the fire when the door is shut; *i* is the door of the stove by which fuel is introduced; *c* is the chimney-flue. When the ash-pit door and the stove-door are shut, the quantity of air admitted by the valved opening in the ash-pit is only just sufficient to support combustion, and only a small corresponding quantity of air can pass away by the chimney. The whole box then soon becomes filled with hot air, or smoke from the fire circulating in it, and rendering it everywhere of as uniform temperature as if it were full of hot water. This circulation takes place,

Fig. 364.

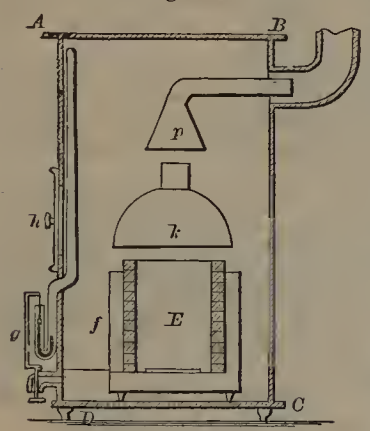


The Arnott Stove.

because the air in the front chamber around the fire-box, and which receives as a mixture the hot air issuing directly from the fire, is hotter, and therefore specifically lighter, than the air in the posterior chamber, which receives no direct heat, but is always losing heat from its sides and back; and thus, as long as the fire is burning, there must be circulation. The whole mass of air revolves, as marked by the arrows, with great rapidity. The quantity of new air rising from within the fuel, and the like quantity escaping by the flue *c*, are very small, compared with the revolving mass. The methods of regulating the supply of air will be noticed presently.

With this stove, Dr. Arnott, during the severe winter of 1836–37, was able to maintain in his library a uniform temperature of from 60° to 63°. The quantity of coal used (Welsh stone-coal) was, for several of the colder months, 6 lbs. a day,—less than two cents' worth,—a smaller expense than that of the wood used in lighting an ordinary fire. The grate or fire-box, fully charged, held a supply for twenty-six hours.

Fig. 365

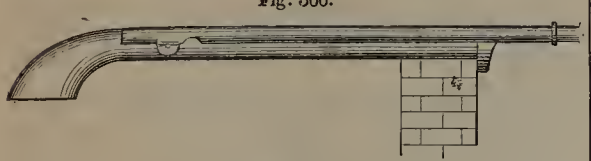


The Arnott Stove.

Another common form of this stove is shown in Fig. 365. *A B C D* is the outer casing; *E* the fire-box over which is a dome *k*, with a funnel *p*, to carry off the products of combustion; *h* is the stove-door, and *g* the regulator by which air is admitted. The device for automatically regulating the supply of air is described under THERMOSTAT (which see).

Ar'que-buse. This piece, an early attempt at a portable fire-arm, had a massive stock laid to the

Fig. 366.



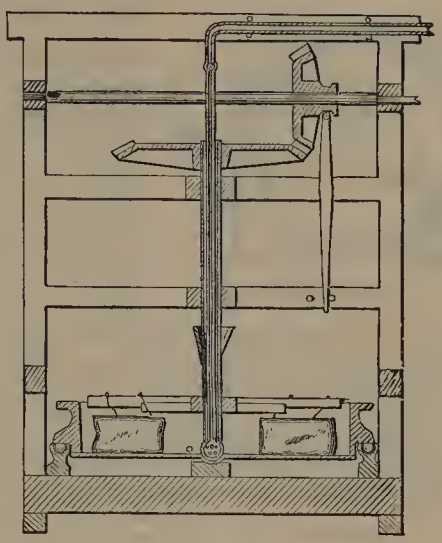
Arquebuse.

shoulder, and an offset near the muzzle by which it might be rested against an object, to break the recoil. It was fired by a match. It was used in the battle of Morat, where the Swiss defeated Charles the Bold, 1476.

Ar-ras'tra. One form of machine for comminuting ore. The name is derived from the Spanish word meaning "to drag," and is indicative of the machine. It consists of a pan in which the ore is placed, and a vertical rotating post, to whose radial arms are attached thongs by which blocks or mullers are dragged over the ore in the pan. They are very common in Mexico, where they operate upon argentiferous ores, and, according to Humboldt, do excellent work. They have been superseded to some extent by other forms of grinding-mills. See AMALGAMATING MILLS; ORE-STAMP; ORE-CRUSHER.

Three arrastras are patented in the United States.

Fig. 367.

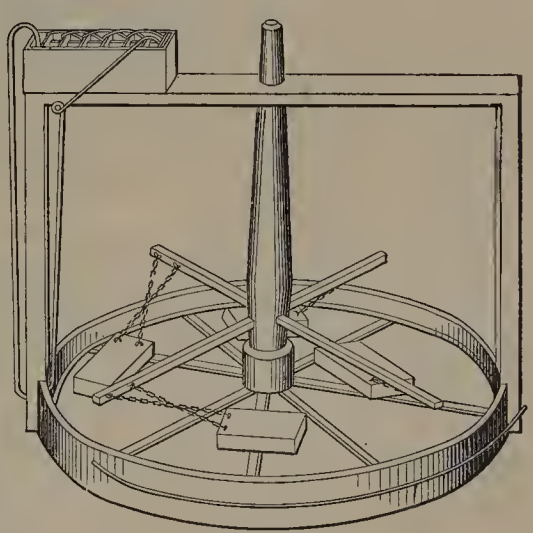


Arrastra.

Fig. 367 has the distinct arrastra characteristics, and is designed for the reduction of precious metals from ores and tailings: it has a cast-iron pan provided with two flanges, placed on opposite sides, and terminating in a ball-pivot, which rests in a cup-shaped bearing on the frame, by which means the arrastra can easily be tipped when the contents are to be drawn off. A cup-shaped cavity serves also as a bearing for a ball-pivot at the lower end of the hollow shaft.

In another form the circumferential band on the inside surface of the arrastra is connected with the

Fig. 368.

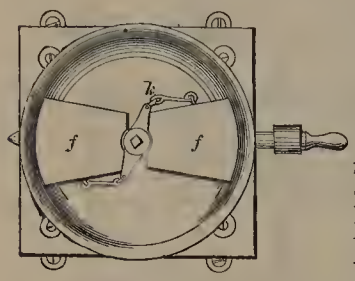


Arrastra.

positive pole of the battery, and the metallic radial gutters are attached to the encircling wire connected to the negative pole. The arrastras being filled with the pulverized ore, water, and mercury, the electric current is caused to pass through the mass, and is intended to facilitate the separation of the metals from their chemical combinations, and further their amalgamation with the mercury.

Fig. 369 is designed as an improvement on the Bertola Mill, October 20, 1857, but differs from it in the fact that the mullers *f* are linked to the arms

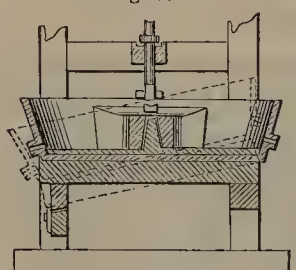
Fig 369.



Bertola's Arrastra.

k of the rotating-shaft, so that each is free to accommodate itself to the material over which it is dragged. The basin in which the mullers revolve consists of a circular iron trough through whose center the rotating axis passes up, being driven by machinery beneath. The muller, in his former patent, was not operated as in an arrastra, was not dragged, but was a block slipped over the central boss in the pan, and formed of an annular disk from whose opposite edges a portion was removed, leaving concave sides. The bottom of the muller was grooved, and the part removed left spaces for the ore on each side, between it and the basin. It was revolved by a shaft above, lowered into operative contact with it as required, and the pulp was discharged by openings near the bottom, which were unstopped when the pan was tilted on a horizontal axis. Openings above and at the bottom, respectively, discharge the water and the amalgam pulp.

Fig. 370.



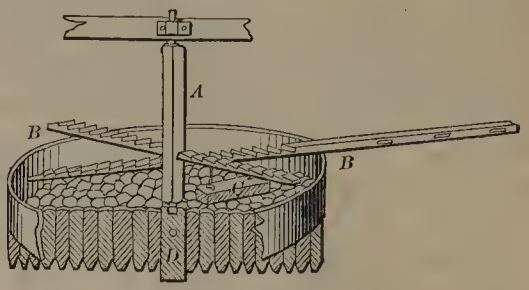
Bertola's Mill, 1857.

The arrastra, as usually constructed, and described by Phillips, consists of a circular pavement of stone, about twelve feet in diameter, on which the quartz is ground by means of two or more large stones or mullers dragged continually over its surface, either by horses or mules, but more frequently by the latter. The periphery of the circular pavement is surrounded by a rough curbing of wood or flat stones, forming a kind of tub about two feet in depth, and in its center is a stout wooden post, firmly bedded in the ground, and standing nearly level with the exterior curbing.

Working on an iron pivot in this central post is a strong, upright wooden shaft, secured at its upper extremity to a horizontal beam by another journal, which is often merely a prolongation of the shaft itself. This upright shaft is crossed at right angles by two strong pieces of wood, forming four arms, of which one is made sufficiently long to admit of attaching two mules for working the machine. The grinding is performed by four large blocks of hard stone, usually porphyry or granite, attached to the arms either by chains or thongs of rawhide, in such a way that their edges, in the direction of their motion, are raised about an inch from the stone pavement, while the other side trails upon it. These stones each weigh from three to four hundred pounds, and in some arrastras two only are employed, in which case a single mule is sufficient to work the machine. Fig. 371 is a sectional view of a Mexican arrastra as usually constructed ; *A* is the upright shaft ; *B*, the arms, to which the mullers *C* are attached ; and *D*, the central block of wood in which the lower bearing works.

Some of the arrastras used by Mexican gold-miners, for the purpose of testing the value of quartz veins, are very rudely put together, the bottom being made of unhewn flat stones laid down in

Fig. 371.



Mexican Arrastra.

clay ; but in a well-constructed arrastra, intended to be permanently employed, the stones are carefully dressed and closely jointed, and after being placed in their respective positions, are grouted-in with hydraulic cement.

Ar-rest'er, Light'ning. An instrument used on telegraph-lines, by which static electricity of high tension (lightning) is discharged from the line to the earth, to prevent injury to the telegraph instruments or the operators.

It consists of an interposed resisting medium which is traversed by a current of high tension, and allows the charge to pass to the earth, but which opposes the passage of the ordinary voltaic current. See LIGHTNING ARRESTER.

Ar'ris. The external angle or edge formed by the meeting of two plane or curved surfaces, whether walls, or the sides of a stick or stone.

Ar'ris-fil'let. A triangular piece of wood placed under a lower course of slates, tiles, or shingles.

Ar'ris-gut'ter. (*Carpentry.*) A V-gutter fixed to the dripping-eaves of a building.

Ar'ris-pie'ces. The portions of a built mast beneath the hoops.

Ar'ris-wise. Diagonally arranged ; said of tiles or slates.

Ar'row. The missile which is projected by a bow. Bundles of arrows were called *sheaves*.

It is usually of reed or of wood, and tipped with the best accessible materials ; such as bone, flint, obsidian, metal.

The old English rule was to have the arrow half the length of the bow, and the latter the length of the archer, so that a *cloth-yard shaft* was used by a man six feet high.

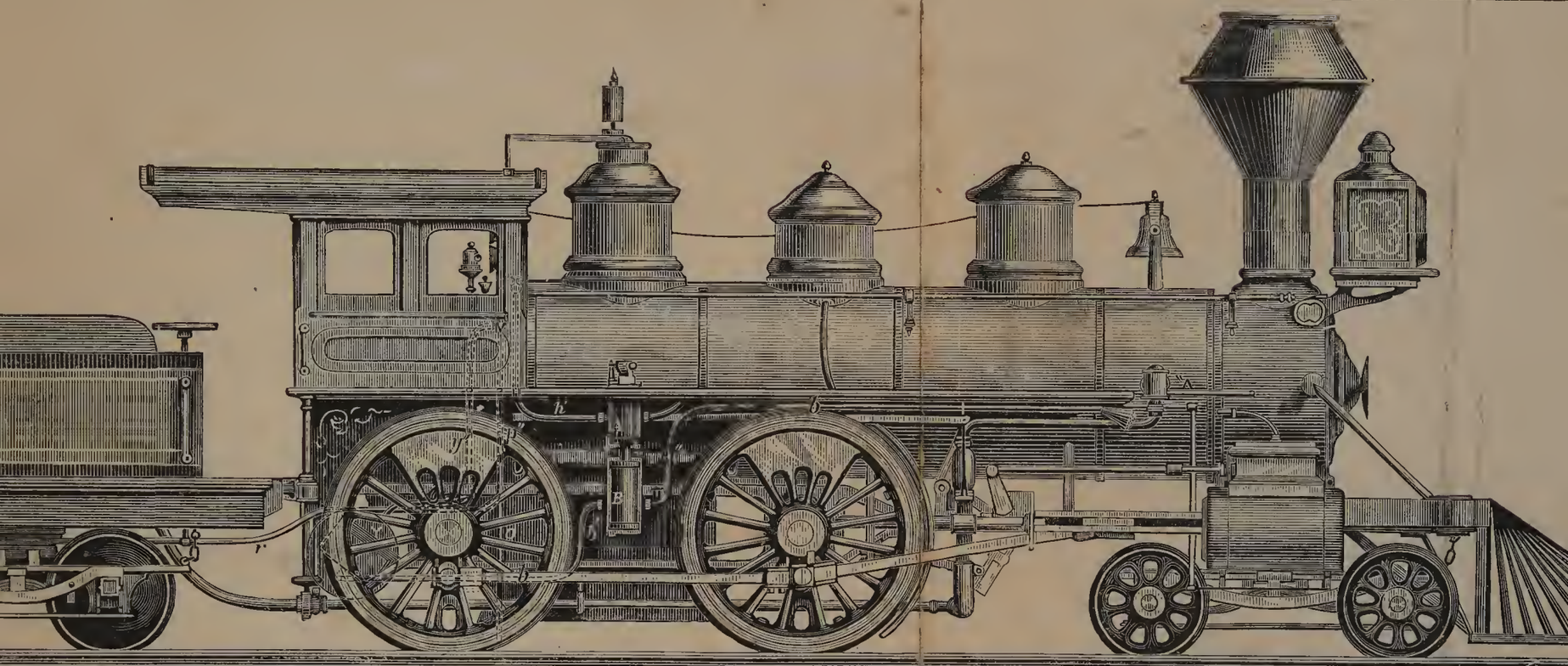
The *bolt* was a peculiar arrow adapted to be shot from a cross-bow. The arrow of an arbalest was termed a *quarrel*.

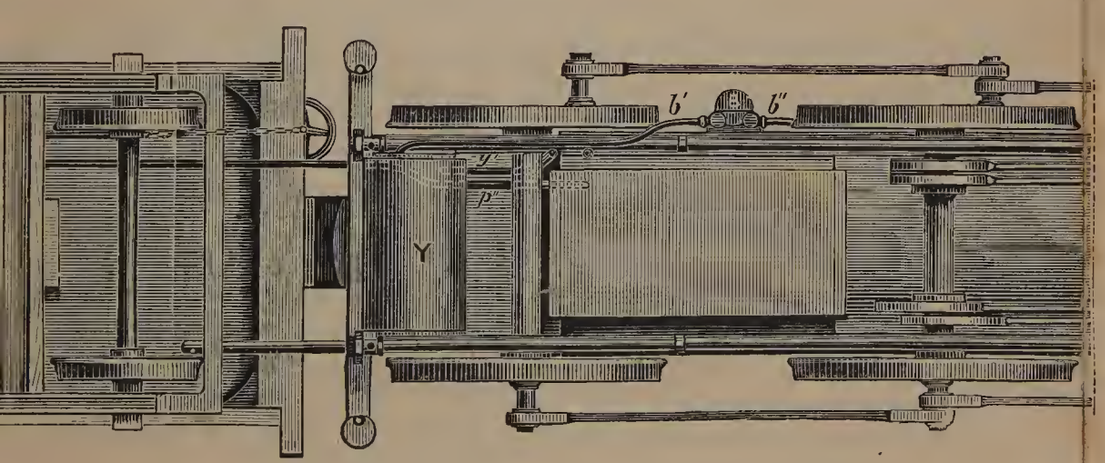
Immense quantities of flint arrow-heads are found in the Celtic barrows throughout Europe. The arrow-heads of the Scythians and Greeks were of bronze, and had three flanges like a bayonet ; such have been found at Persepolis and Marathon. The "barbarians," say the classic writers, use barbed (*aduncæ, hamatæ*) and poisoned (*venenatæ*) arrows. The poison on the arrow was called *toxicum*, from its relation to the bow, and the word was extended to poison in general.

The shaft was of polished wood, cane, or reed. The latter actually gave names to the weapon, — *arundo, calamus*. The Egyptians used reed shafts ; their arrows were from 22 to 34 inches in length, and are yet extant.

The monuments show feathered shafts.

In the time of Homer, arrows were sometimes poisoned. The poisoned arrows of the Indians of Guiana are blown through a tube. They are made of the hard wood of the *Cokarito* tree, are about the size of a





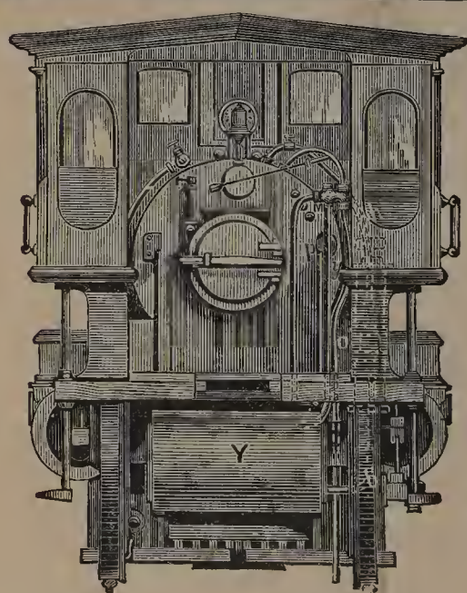


Fig. 3.

WESTINGHOUSE'S ATMOSPHERIC BRAKE FOR RAILWAY CARS.

See page 356.

knitting-needle nine inches long, and mounted on a yellow reed four or five feet long. One end is sharpened, and poisoned with *woorai;* the rear end receives a pledget of cotton to act as a piston in the tube. The effective range is about forty yards. The hardwood spike can be removed at pleasure; twelve or fifteen such spikes are carried by the hunter in a little box, made of bamboo. The poisoned spike is cut half through, at about a quarter of an inch above the point where it fits into the socket of the arrow; and thus, when it has entered the animal, the weight of the shaft causes it to break off, the shaft falls to the ground uninjured, and is fitted with another poisoned spike and used again.

In like manner the arrows of the Bushmen, Africa, often have the shafts partly cut through, so that they may break and leave the point in the wound.

The serrated weapon of the sting ray is used by the Malays for heading some of these blow-arrows, with the express intention that they might break off in the wound.

The arrow-heads of the Shoshones of North America, said to be poisoned, are tied on purposely with gut in such a manner as to remain when the shaft is withdrawn.

A similar idea is carried out in a Venetian dagger of glass with a three-edged blade, having a tube in the center to receive poison. By a certain wrench the blade was broken off, and remained in the wound.

"In passing overland from the Essequibo to the Demerara," says Waterton, "we fell in with a herd of wild hogs. An Indian let fly a poisoned arrow at one of them; it entered the cheek-bone and broke off. The hog was found dead about 170 paces from the place where he had been shot. He afforded us an excellent and wholesome supper." The wild tribes of the Malayan peninsula, who use poisoned arrows, eat the meat of animals killed by these deadly weapons, without even troubling themselves to cut out the wounded part.

There is reason for supposing that the discovery of the various poisons used for weapons, and the practice of applying them to such a purpose, arose spontaneously and separately in the various quarters of the globe. Poisoned weapons are used by the Negroes, Bushmen, and Hottentots of Africa; in the Indian Archipelago, New Hebrides, and New Caledonia. They are employed in Bootan, Assam, by the Stiens of Cambodia, and formerly by the Moors of Mogadore. The Parthians and Scythians used them in ancient times.

The composition of the poison varies in different races; the Bushmen, Hottentots, and others, using the venomous secretions of serpents and caterpillars. In the Bosjesman country, Southern Africa, the natives hunt the puff-adders, in order to extract the poison. They creep upon the reptile unawares, and break its back at a single blow. The poison-glands are then extracted; the venom is very thick, like glycerine, and has a faint acid taste. This is mixed, on a flat stone, with an acrid poisonous gum, called "parki"; after being worked until it becomes of the consistency of thick glue, it is spread over the barbed head of the arrow and for about two inches up its point. The arrows are then dried in the sun. Each warrior carries some half-dozen of these devilish weapons, a wound from one of which is as deadly as the bite of the adder itself.

In Ceylon the cobra-tel poison is extracted from certain venomous snakes, such as the Cobra de Capello (from which the poison takes its name), the Carawella, and the Tic polonga; arsenic and other drugs are added, and the whole is "boiled in a human skull." Three Kabra-goyas (*Hydrosaurus salvator*) are tied near three sides of the fire, with their heads toward it; they are tormented with whips to make them hiss, so that the fire may blaze! The froth from their lips is added to the boiling mixture, and as soon as an oily scum rises to the surface, the "cobra-tel" is complete. Probably the arsenic is the most active ingredient in this poison.

The Ceris are said to prepare poison for their arrows in the following manner: "They first kill a cow, and take from it its liver; they then collect rattlesnakes, scorpions, centipedes, and tarantulas, which they confine in a hole with the liver. The next process is, to beat them with sticks, in order to enrage them; and, being thus infuriated, they fasten their fangs and exhaust their venom upon each other and upon the liver. When the whole mass is in a state of corruption, the women take their arrows and pass their points through it; these are then allowed to dry in the shade."

The Indians of Choco and Barbacoas use the "Veneno-derana," or frog poison, which is obtained by placing a species of yellow frog, that frequents the swamps, over hot ashes, and scraping off the viscid humor that arises. After thus torturing the frogs, they are allowed to escape, in order that they may serve another time. "Veneno-de-culebra," or snake poison, is also said to be used in Choco.

(*Fortification.*) An advanced work at the foot of the glacis, consisting of a parapet whose faces form a salient angle. It has communication with the covered way cut through the glacis.

(*Surveying.*) One of the iron-wire pins employed in marking the chainage. One is placed in the ground at the end of each chain.

An *arrow* is ten inches long, with a loop at the upper end, and is all the better for a red flag to render it conspicuous.

Called also a *chain-pin.*

Ar'se-nic. A soft, brittle, and poisonous metal of a steel-gray color. Equivalent, 75; symbol, As.; specific gravity, 5.7. It volatilizes, exhaling an odor of garlic; fuses at 400° Fah., and is easily inflamed. It combines with oxygen in two proportions, forming arsenious and arsenic acids. The former salt is As. 75, O. 24; the latter, As. 75, O. 40. The former is the common white arsenic of commerce, very poisonous, and a dull white powder, sp. gr. 3.07.

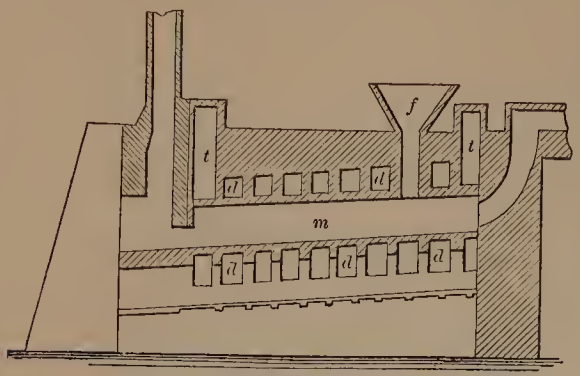
It is used to alloy lead for shot-making, causing the metal to pour more readily, and hardening the shot.

Ar'se-nic Fur'nace. A furnace in which arsenical pyrites is decomposed by heat, producing white arsenic, which is an oxide of the metal chemically known as arsenious acid, the arsenic of commerce. Arsenic is combustible, oxidizing so rapidly as to burn with a livid flame, the fumes being condensed in large chambers which resemble the successive stories of a house. The floors have openings, so that the fumes traverse each apartment, and the light powder is deposited.

The furnace is a muffle *m*, with an inclined sole, and having a fire-chamber beneath. The sole rests upon brickwork which has numerous openings, forming circulatory flues *d* around the muffle. The arsenical pyrites is introduced at the hopper *f*, and the smoke escapes by the flues *t t*.

The condensing chambers have openings by which the collected arsenic on the respective floors is removed, the lower chamber being entered by the duct *o*, which proceeds from the muffle.

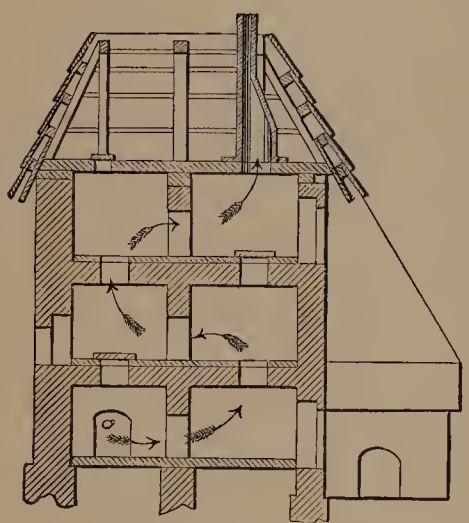
Fig. 372.



Arsenic Furnace.

The deposit in the lowest chamber is the purest.

Fig. 373.

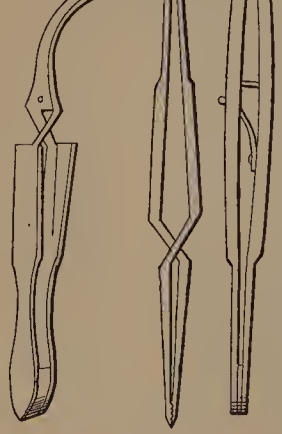


Condensing Chamber.

Ar-te'ri-al Com-pres'sor. (*Surgical.*) A form of tourniquet invented by Signoroni, to be used in amputations at the hip joint, to control the circulation at the groin without impeding the return by the veins.

Ar'te-ry Claw. (*Surgical.*) A locking forceps for seizing an artery.

Fig. 374.



Artery Forceps.

Ar'tery For'ceps. An instrument for catching an artery. These forceps are made straight, curved, plain, or rat-toothed, spring-open, spring-shut, or catch.

The illustration shows three forms.

Ar'te-ry-o-tome'. A post-mortem or dissecting instrument, for slitting an artery.

Ar-te'sian Well. Artesian wells are so called because it was generally supposed that they were first used in the province of Artois, France. They appear, however, to have existed in Egypt at a very remote date, and are said to be found in the province of On-Tong-Kiao, in China, of the depth of from 1,500 to 1,800 feet. The principle of their action is this: water percolating through pervious strata, such as sand, gravel, or chalk, is finally arrested in its downward course by an impervious stratum of rock or clay, causing it to accumulate in the pervious stratum above as in a reservoir, and when the source of supply is higher than the level of the ground at the place where the well is bored, the water will rise to the surface, or even considerably above it; in many cases issuing from the mouth of the well with sufficient force to throw a jet of the water to a great hight, or admit of its being carried high enough for distribution to the upper stories of buildings.

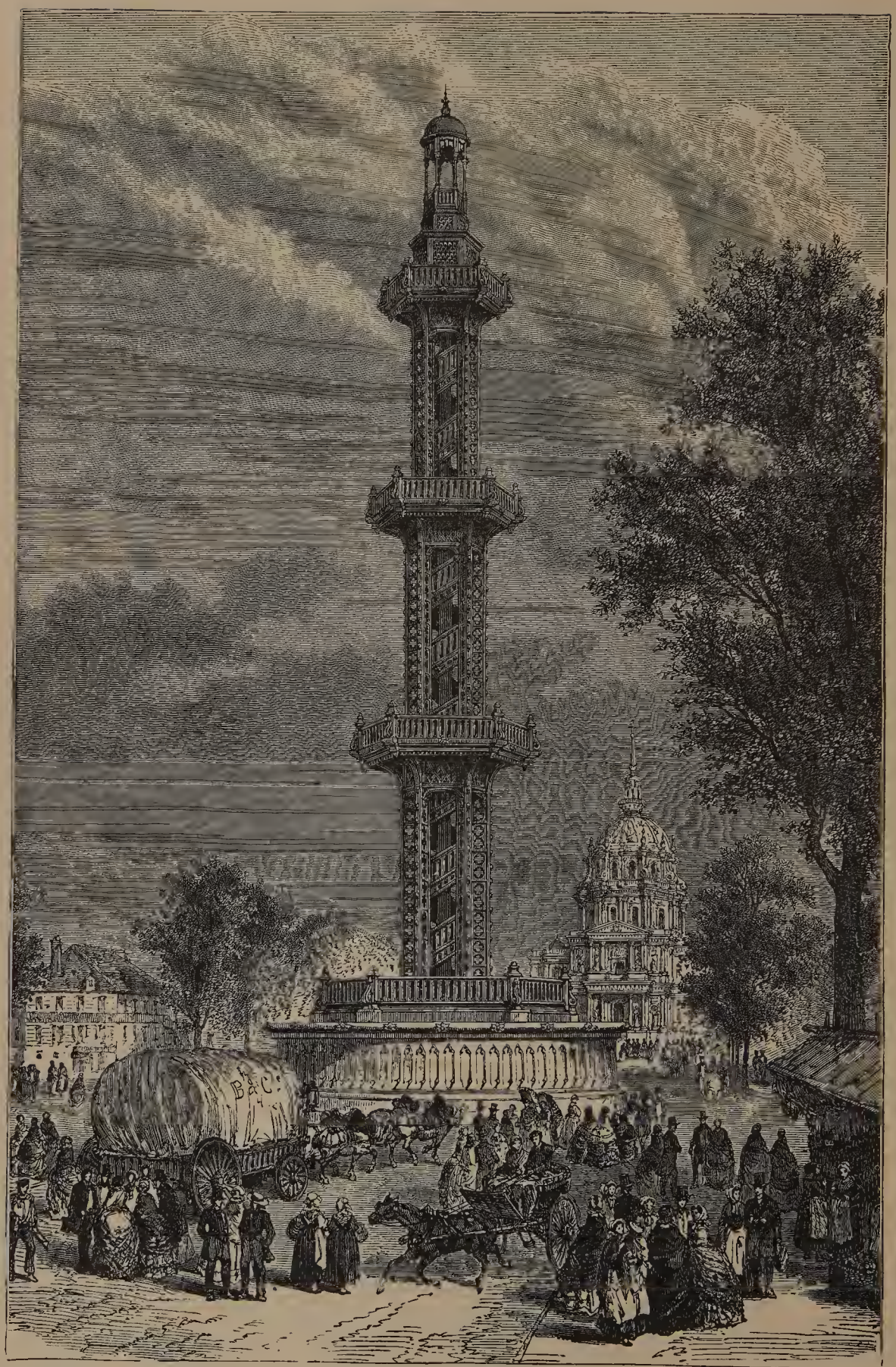
The term "artesian" is only properly applied to wells in which the water rises to or above the surface, so that in case a large number are collected in a single neighborhood, some or all of them, particularly those toward the higher part of the basin, may become converted from artesian into ordinary wells. In the London basin, where a great number of artesian wells have been bored, the general level of the water has been very much diminished.

It generally happens that more than one, frequently many, water-bearing strata are penetrated before one is reached which has a sufficient head to cause an overflow at the surface; in such cases others besides the lower one may be made available, if thought advisable.

The wells of the London basin will perhaps afford as good an illustration of the theory and action of artesian wells as any other example; the character and succession of the beds having been more carefully studied and worked out than almost any others where such wells are located.

These wells derive their supply from the pervious strata of the plastic clay and chalk. These strata are covered in part by the formation called the London clay, which is, in most of its beds, tough and impermeable to water, so that the rain falling on those parts of the porous chalk and other pervious strata below it, which are not covered by the superjacent impervious clay, percolates through them till its farther progress downward is stopped by the "gault," another stratum of impervious clay, and accumulates tween it and the overlying clay, which acts as a cover to this vast subterraneous reservoir to the level of the line *B A*. The water, reaching points, as *C*, at the lower levels of the junction of the chalk and clay, the pervious and the impervious strata, comes to the surface in the form of springs which act as discharge-outlets. In this case a horizontal line, as *A B*, drawn through *C*, indicates the general level of the water in the basin, unless disturbed by faults or shifts in the strata permitting a part to be carried off at a lower level. In the latter case, if the outlet had an area of capacity for carrying off an amount in excess of the supply received from the clouds, it would determine the water-level; if less, the level would fluctuate somewhere between this lower point of discharge and the line *A B*, in proportion to the amount of rain falling on the exposed portions of the pervious strata.

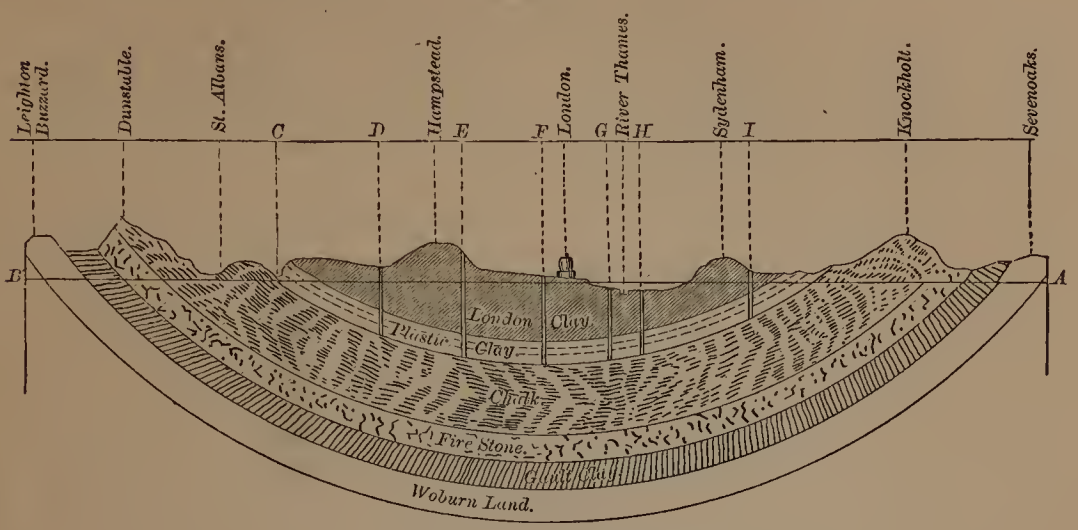
If a boring be made anywhere through the overlying clay beds, it is evident that the water will rise by hydrostatic pressure until it has attained the same level as in the chalk beds below, and if the surface of the ground at that point be below this level, the water will rise to the surface and overflow as at *G* or *H*, which it did a few years ago in the valley of the Thames between London and Brentford, though it is said that latterly there has been an average fall of about two feet per year in the wells of the London basin, so that in many of those wells



ARTESIAN WELL.

PLATE V. GRENELLE, PARIS, FRANCE. See page 163.

Fig. 375.

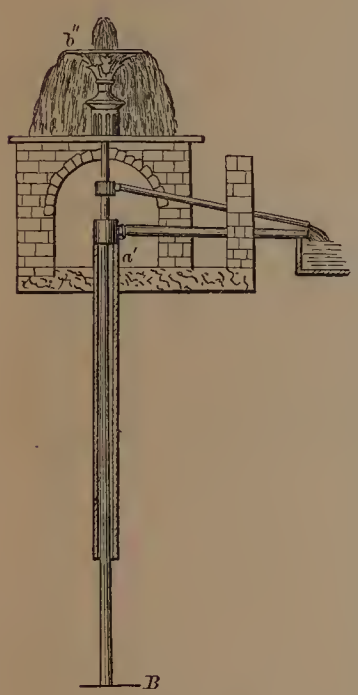


Section of the London Basin.

which formerly overflowed the water is now raised by pumps.

At St. Ouen, in France, water is brought up from two strata at different levels, the ascending force of the water from the lower stratum being greater than that in the upper. This is effected by means of two pipes, one within the other, with a sufficient interval between them to allow the free passage of water. The smallest pipe brings up the water from the lower stratum *B* to the level of the highest part of the fountain *b″*, while the water from the upper stratum, which does not attain so high a level, passes up through the outer pipe to *a′*; by this means, should the water from the lower stratum be pure and that from the upper impure, the former may be brought up and discharged separately without being mingled with or contaminated by the former. Both these streams are used for supplying the canal basin at St. Ouen, which is above the level of the Seine.

Fig. 376.



Well of St. Ouen.

The well at Calais is 1,138 feet, and that at Douchery, in the Ardennes, France, 1,215 feet, in depth. The English wells are of less depth, varying from 70 or 80 to 620 feet. The fountains in Trafalgar Square, London, are supplied by wells of this kind, 393 feet deep. Those of London are all in the chalk, and it is believed that by deeper boring, so as to reach either the upper or lower green-sand formations, a more ample supply of water could be obtained.

The essential apparatus for boring as generally practiced consists of an auger or borer attached to rods (which are successively screwed on to each other as the work progresses, and which afford a measure for the depth of the boring), and tubes of an exterior diameter equal to that of the well, which are pushed down one after another to prevent the caving in or filling up of the well by earth or rock. One of the most celebrated artesian wells is that at Grenelle, a suburb of Paris, which took nearly seven years and two months of difficult labor to complete; it is 1,802 feet in depth, and when the water-bearing stratum of green-colored sand was reached, the water was discharged at the rate of upwards of 880,000 gallons in 24 hours; the force was such that the water could be carried to a hight of 120 feet above the surface.

The temperature of the water from the depth of 1,802 feet was considerably higher than the mean temperature at the surface. In the cellars of the Paris Observatory, at a depth of 94 feet, the thermometer was found constantly to remain at 53°.06 Fah.; in the chalk, at a depth of 1,319 feet, it marked 76°.3; in the gault, at 1,657 feet, 79°.6; and the water flowing from the well has a uniform temperature of 81°.8, indicating a rate of increase of 1°.7 for each 100 feet below the limit of constant temperature.

The springs which supply the King's Bath, at Bath, England, have a temperature of 117°, and the spring of Orense, in Gallicia, has a temperature of 180° Fah.

The artesian Brine-well of Kissingen, in Bavaria, was begun in 1832, and in 1850 water was reached at 1,878 feet. The depth reached by farther boring was about 2,000 feet. The water has a temperature of 66° Fah., and issues at the rate of 100 cubic feet per minute. The ejecting force is supposed to be derived from a subterranean atmosphere of carbonic-acid gas, acting with a force of 60 atmospheres. The tubings are concentric, water rising between the outer and middle tubes, passing down between the middle and inner tubes to the bed of rock salt, where it is saturated, and then raised in the middle tube to the surface.

The artesian well at Passy, near Paris, is probably the largest well of the kind that has ever been sunk. It is carried through the chalk into the lower green sands, which were reached at a depth of 1,913 feet, the bore finishing with a diameter of two feet.

Six years and nine months were occupied in reaching the water-bearing stratum, when the yield was 3,349,200 gallons per day of 24 hours, subsequently increased to 5,582,000 gallons, and then continued at 3,795,000 gallons per day. The total cost of the well was £ 40,000. It was lined with solid masonry for a depth of 150 feet, then wood and iron tubing was introduced to 1,804 feet from the surface, and below that there was a length of copper pipe pierced with holes.

The variety of boring tools which have been employed in making artesian wells is very great, and the utility of some of those figured and described in works on the subject, if one may be allowed to judge from their shape and appearance, is very questionable. The mode adopted by the Chinese, who have for many ages been in the habit of boring for salt or fresh water is one of the most primitive.

Their wells are often from 1,500 to 1,800 feet deep, and bored in the solid rock. A wooden pipe five or six inches in diameter inside is sunk into the earth, and covered with a stone having the same aperture as the pipe. A steel tool weighing 300 or 400 pounds, concave above and rounded beneath, is suspended by a cord from the extremity of a lever and lowered down the tube ; by leaping on the end of the lever, the piece of steel is suddenly elevated about two feet and allowed to fall by its own weight, being partially rotated at each movement. When three inches of rock have been crushed, the steel is raised by means of a pulley, bringing with it the material which has accumulated on its upper concavity.

Fig. 377.

Rock-Drill.

Should the attachment of the steel head be broken, another steel head is employed to break the first, an operation perhaps requiring months. Under favorable circumstances it is said nearly two feet of rock may be penetrated in 24 hours.

A modification of the above has been employed in Europe, in which the upper part of the tool is inclosed in a cylinder (see Fig. 377). These are suspended by a rope, the twisting and untwisting of which imparts a sufficient circular motion. When theapparatus is withdrawn from the hole, the lower end of the tool closes the bottom aperture of the cylinder, which brings up the mass of comminuted rock to the surface.

Fig. 378.

Well-Boring.

A common mode of boring is shown in Fig. 378. Two men walk around and turn the handle of the boring-tool, which is screwed into an iron rod. In moderately soft ground the weight of the two men and the rotation of the handle will cause the boring-chisel to penetrate, but in rock it requires to be hammered down, the men shifting its position from time to time to enable it to act on a fresh portion of the rock. This operation is greatly facilitated by suspending the boring-rods from a beam, fixed at one end and worked by a man at the other, assisting by its elasticity the efforts of those below in alternately raising and depressing the tool to give it the necessary pounding motion. When the hole has by this means been opened as far as the length of the tool will allow, it is withdrawn, and a valved cylindrical auger (Fig. 379) introduced, which being turned, the valve is opened by the pressure of the comminuted rock or earth below, and fills the cylinder, which is then withdrawn. See AUGER ; EARTH-BORING.

Fig. 379.

Hole-Clearer.

For raising and lowering the apparatus, a tripod formed by three poles is erected over the mouth of the pit, from which a block and attached tackle is suspended ; this is made fast to a claw, represented at Fig. 380, which is passed under the shoulders of the upper rod. When this is raised sufficiently, a fork is passed under the shoulders of the section below, the upper one is detached by means of a suitable wrench, and the lifting again proceeded with. Instead of the springing beam, a windlass is sometimes employed for giving the percussive motion to the tool ; several turns of the suspending rope being taken around the windlass, the friction of the rope will be sufficient, when aided by the strength of a man having hold of the end of the rope, to prevent it from slipping when the windlass is turned, the man taking up the slack and aiding the upward motion. When the whole apparatus is raised a short distance in this way, the rope is slacked, and the apparatus falls with its whole weight, penetrating and crushing the rock below. The windlass is kept constantly in motion in one direction, and the percussive motion is maintained by alternately holding fast and slacking the end of the rope.

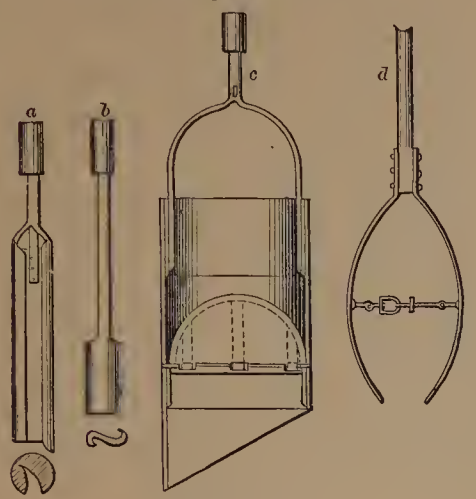
Fig. 380.

Rod-Claw.

In Fig. 381, *a* is a plan and elevation of an auger used for boring in clay or loam. *b* is an "S" chisel for hard rock. *c* exhibits a hollow valved auger for boring through sand or bringing up rock previously pulverized by the chisel. *d* is a spring reamer for enlarging a hole previously bored ; this is passed down through the pipe, and, on reaching its bottom, expands to a distance regulated by the screw and swivel connecting the two spring cutters, the cutting edges of which are placed reversely. Figs. 382 and 383 exhibit different kinds of tools for earth and rock.

The rods frequently break in boring, and for raising the portion broken off below, various devices have been contrived, one of the most simple of which is represented in Fig. 384. It consists merely of a worm, which screws around the rod, which is only retained by friction when lifting. This is only available when the weight of the broken part is insufficient to overcome the friction.

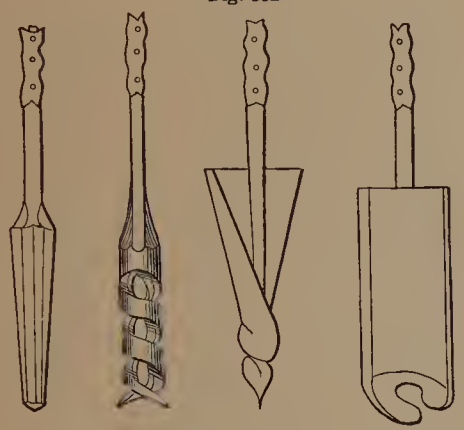
Fig. 381.



Well-Boring Tools.

The forms of boring and elevating tools which have been employed have been much modified by

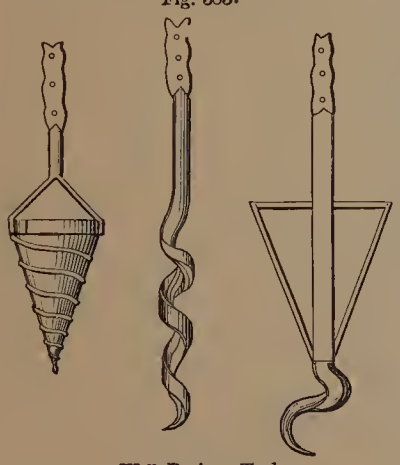
Fig. 382.



Well-Boring Tools.

the experience in boring the oil-wells of the petroleum region. A great impetus was given to the exercise of ingenuity in this line by the exigencies of this branch of industry; the inventions including boring-tools, tool-grabs, tool-jars, derricks, rod-couplings, reamers, well-tubes and couplings, tube-packing, "seed-bags," ejectors, and engines specifically adapted to sinking the shaft and raising the oil.

Fig. 383.



Well-Boring Tools.

The boring of the artesian well at Belcher's Sugar Refinery, St. Louis, was effected by a simple wedge-shaped drill, the size of which varied according to the diameter of the bore; this drill was screwed to a wrought-iron bar 30 feet long and about $2\frac{1}{2}$ inches diameter, weighing several hundred pounds. To the bar was screwed a pair of slips, so that the drilling was effected by the weight of the bar alone. To this were fastened the poles, each of which was 30 feet long. These were screwed together, and were made of two pieces of split hickory-wood joined and riveted in the center. To the last pole was fastened a chain, the other end of which was attached to a spring-beam worked by a steam-engine running with a speed of about 80 revolutions per minute and having 14 inches stroke. The boring-apparatus was constantly turned by hand-power. The boring was commenced in the spring of 1849, and continued at intervals till March, 1855. For performing all the work connected with the boring, the labor of four men was, in general, daily required. This well was finished at the expiration of 33 months' steady work, and attained a depth of 2,197 feet, at a cost of $10,000; that at Grenelle, 400 feet less in depth, was more than seven years in boring, and is said to have cost about $70,000. From this depth of 2,197 feet the water can be carried to a hight of 75 feet above the surface. It is a mineral water, having a salty taste and a strong odor of sulphur, and possesses great medicinal virtues.

Fig. 384.

Rod-Lifter.

The well bored at the county buildings of St. Louis Co., Missouri, has reached a depth of 3,235 feet without obtaining a flow of water.

The artesian wells at Chicago are 700 feet deep, and discharge about 1,250,000 gallons daily, with a head of 125 feet above the surface of Lake Michigan. The water is very pure and cool for the depth from which it comes, having a temperature of 57°.

The well at Louisville, Kentucky, is even deeper than this, and yields a medicinal water allied in quality to the Blue Lick and Big-Bone Lick, springs of the same state.

Some years ago a boring was commenced in the public square surrounding the State House at Columbus, Ohio, with the intention of endeavoring to obtain a head of water which could be carried to the upper part of that building for its ordinary supply, as well as in case of fire, etc. A depth of rather more than 2,700 feet was penetrated, mostly, if not entirely, through Silurian strata, but none was reached where the water had a sufficient head to rise to the surface.

Artesian wells were made in ancient times in the Oasis of El-Bacharich, and were described by Olympiodorus, a native of Thebes, who lived in the fifth century A. D. Their depth is said to be from 200 to 500 cubits, and the water issues at the surface. They have been noticed by Arago. A Frenchman has reopened several of those which had become stopped. The reopened wells are from 360 to 480 feet deep.

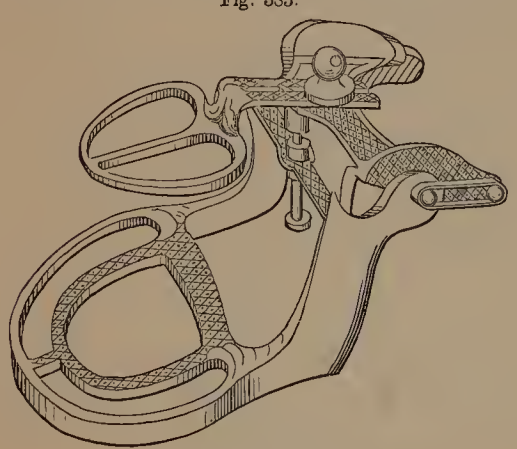
The *Moniteur Algérien* gives an interesting report on the newly bored Artesian wells in the Sahara Desert, in the province of Constantine. The first well was bored in the Oasis of Oued-Rir, near Tamerna, by a detachment of the Foreign Legion, conducted by the engineer, M. Jus. The works were begun in May, 1856, and, on the 19th of June, a quantity of water, of 1,060 gallons per minute, and of a temperature of 79° Fah. rushed forth from the bowels of the earth. The joy of the natives was unbounded; the news of the event spread towards the south with unexampled rapidity. People came from long distances, in order to see the miracle; the Marabouts, with great solemnity, consecrated the

newly created well, and gave it the name of "the well of peace." The second well, in Temakin, yielded 9 gallons, of 79° temperature, per minute, and from a depth of 279 feet; this well was called "the well of bliss." A third experiment, not far from the scene of the second, in the Oasis of Tamelhat, was crowned with the result of 33 gallons of water per minute. The Marabouts, after having thanked the soldiers in the presence of the whole population, gave them a banquet, and escorted them in solemn procession to the frontier of the oasis. In another oasis, that of Sidi-Nached, which had been completely ruined by the drought, the digging of "the well of gratitude" was accompanied by touching scenes. As soon as the rejoicing outcries of the soldiers had announced the rushing forth of the water, the natives drew near in crowds, plunged themselves into the blessed waves, and the mothers bathed their children therein. The old Emir could not master his feelings; tears in his eyes, he fell down upon his knees, and lifted his trembling hands, in order to thank God and the French. This yields not less than 1,136 gallons per minute, from a depth of 177 feet. A fifth well has been dug at Oum Thiour, yielding 29 gallons per minute. Here a part of the tribes of the neighborhood commenced at once the establishment of a village, planting at the same time hundreds of date-palms, and thus giving up their former nomadic life.

Ar-tic'u-la-tor. 1. An apparatus for obtaining correct articulation of artificial dentures.

The lower plate is modeled from the natural jaw,

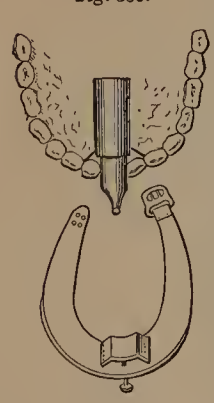
Fig. 385.



Denture Articulator.

and moves on cone-shaped pivots in V-shaped grooves without hinges, being retained in position by elastic rubber bands or rings. A backward, forward, and lateral motion is provided for, corresponding with the movements of the natural jaw, by which the arrangement of the denture can be practically tested without disturbing the articulation. The upper plate has a backward and forward movement of two inches, and may be retained at any point by the set-screw. The upper plate has a double bend, so that, when reversed from the position shown in the cut, an increase of one inch in the space is obtained between the plates, allowing for both upper and lower dentures.

Fig. 386.



Articulator.

2. An instrument for the cure of stammering. A tube in the mouth permits the passage of air, when the muscles of the mouth are suddenly closed by spasmodic action. A strap around the throat has a pad whose pressure is regulated by a spring. Its action is to keep the glottis open, and prevent the spasmodic constriction which is the cause of the trouble in articulation.

Ar-ti-fi'cial ———. An object imitating nature, such as an artificial *stem* or *flower;* sometimes having a prosthetic purpose, as an artificial *limb* or *eye.*

See under the respective heads:—

Arm, Artificial.		Leather, Artificial.	
Auriele	"	Leech	"
Cork	"	Leg	"
Ear	"	Limb	"
Eye	"	Nipple	"
Flowers	"	Nose	"
Foot	"	Palate	"
Fuel	"	Pearls	"
Gems	"	Pupil	"
Gums	"	Stone	"
Hand	"	Teeth	"
Horizon	"	Tympanum	"
Horn	"	Wood	"
Ivory	"		

Ar-til'ler-y. The word seems to have a very extended signification, having been originally applied to military engines of every description capable of throwing heavy missiles, as the ballista, catapult, etc. Uzziah made use of them at Jerusalem 810 B. C. They are described (2 Chronicles xxvi. 15) as "invented by cunning men, to be on the towers and upon the bulwarks, to shoot arrows and great stones withal." The Chinese claim to have used cannon 618 B. C., and engines for throwing heavy stones were used in Sicily 300 B. C. Each Roman Legion under the early emperors was furnished with an artillery train, consisting of 10 larger and 55 smaller engines for throwing stones and darts, which accompanied it on its marches. These engines appear to have corresponded to the siege artillery of modern times, and were merely employed in the attack and defence of fortified places. Their want of portability probably prevented them from being of much service in pitched battles on the open field. The date of the introduction of fire-arms as artillery appears involved in great obscurity. The artillery of the Moors is said to date back to 1118; from the few faint and imperfect allusions which occur here and there in old writers, it seems probable that their invention bore some analogy to rockets, or the projectile was self-propelling.

The following are some of the dates ascribed to the introduction of some military engines and artillery:—

Catapult invented by Dionysius of Syracuse, B. C.	399
Gunpowder artillery used in China . A.D.	85
Cannon throwing stones, weighing 12 pounds, 300 paces	757
The Moors use artillery in attacking Saragossa	1118
The Moors use engines throwing stones and darts by means of fire	1157
The Chinese employ cannon throwing round-stone shot against the Mongols . .	1232
Cordova attacked by artillery . .	1280
A mortar for destroying buildings, etc. described by Al Mailla, an Arab historian .	1291
Gibraltar taken by means of artillery .	1308
A cannon in the arsenal at Bamberg . .	1323
Balls of iron thrown by means of fire used by the Moors	1331

Ten cannon prepared for the siege of Cambray 1339
The Moors defend Algesiras against Alphonso XI. by means of mortars . . . 1343
Four pieces said to have been used by Edward III. at Crecy 1346
An iron gun with a square bore, for carrying a cubical shot of 11 pounds' weight, made at Bruges 1346
Artillery used by the Venetians at the siege of Chioggia 1366
Artillery used by the Turks at the siege of Constantinople 1394
Red-hot balls fired by the English at the siege of Cherbourg 1418
The great cannon of Mahomet II. employed against Constantinople . . . 1453
Louis XI. of France has twelve cannon cast to throw metallic shot, for use as a siege train. 1477
Brass cannon first cast in England . . 1521
Iron " " " " " . . 1547
Howitzers introduced 1697
Maritz of Geneva introduces the method of casting guns solid and boring them out . 1749
Carronades invented by General Melville . 1779

For continuation of the subject and details, see ORDNANCE; MORTARS; PROJECTILES; WEAPONS, etc.

In European services, artillery is divided into

Field Artillery	Horse Artillery
Foot "	Marine "
Garrison "	Siege "
Heavy "	Standing "

Ar-til'ler-y Car'riage. In the United States service, wrought-iron is now exclusively used as a material for garrison and sea-coast gun-carriages.

Experiments have also been made, promising a successful result, upon wrought-iron for field carriages.

The only field carriages so called now used in the United States service are those for the 3-inch rifled and the 12-pounder smooth-bore gun, the 6-pounder smooth-bore, the 12, 24, and 32 pounder howitzers having gone out of use.

The term "*field* carriages" is in the service only applied to such as are employed as light artillery: those adapted for the 4½-inch rifled, the 18 and 24 pounder smooth-bore guns being denominated *siege;* and those for the larger calibers, from 32-pounder to 20-inch, and for the larger rifled guns, being denominated *sea-coast* and *garrison.* The construction of field and siege carriages is necessarily very similar, both being intended to transport the guns mounted on them, as well as to afford a support during firing; while garrison gun-carriages are merely intended to subserve the latter purpose, not requiring to be moved, except from one front of a fortification to another.

The main wooden parts of a field gun-carriage are the stock, the cheeks, and the wheels.

For gun-carriages which are intended permanently to remain in position, an additional fixture is required, — the chassis; a frame, as the word implies, on which the carriage rests, and by means of which it is aimed in a horizontal direction, and upon which it is run backward and forward.

The iron parts of a field gun-carriage are very numerous, the principal being the *lunette* at the end of the stock; the *trunnion plates,* on which the trunnions of the gun rest; the *cap-squares,* which cover the trunnions and prevent the gun jumping off at the moment of firing; the prolonge hooks, around which the prolonge is coiled; and the bands at the ends of the cheeks and around the axle.

There are also arrangements for supporting the two rammers and sponges, the worm, and the maneuvering handspikes.

Ar-til'ler-y Lev'el. An instrument adapted to stand on a piece of ordnance, and indicate by a pendulous pointer the angle which the axis of the piece bears to the horizontal plane. By its means any required angle of elevation is given to the piece.

Ar'ti-mor-an'ti-co. An alloy of tin, sulphur, bismuth, and copper, made in imitation of the ancient jewelry. It resembles gold of 18 carats purity, and is made in Italy for factitious trinkets.

Artz'ber-ger. A device which originated on the continent of Europe, and was used in England in the early part of the present century as an intermediate between the piston-rod and the axle to be driven.

The power of the steam-engine, as in the Griffith Steam Carriage, 1821, is communicated from the piston-rods to the axle of the driving-wheels, through the means of sweep-rods, the lower ends of which are provided with driving pinions and detents, which operate upon toothed gear attached to the driving-wheel axle. The object is to keep the driving-pinions always in gear with the toothed wheels, however much the engine or carriage may vibrate.

As-bes'tus. A fibrous mineral which may be split into threads and filaments and resists fire. It is also known as *amianthus,* or earth-flax. The name indicates the substance, or rather the quality (in Greek, *asbestos,* — inextinguishable). It had many uses among the ancients. Mineralogically speaking, it is a variety of hornblende and pyroxene, and occurs in many parts of the world. It is found in great abundance in a few localities in the United States, and great attention is now directed to fitting it for the uses of the arts and manufactures.

The notices of its uses among the ancients are numerous. Herodotus refers to cloth made of it by the Egyptians. Its uses for paper, napkins, socks, drawers, handkerchiefs, are referred to by Varro, Strabo, and Pliny. Marco Polo mentions it, and Baptista Porta speaks of its being spun in Venice. Asbestus cerements and wrappings for the bodies of the dead previous to incremation were in common use with those whose circumstances permitted it. Shrouds of asbestus of the time of the Roman Emperors have been discovered, and are in the museums of the Vatican and of Naples. The Romans dug their asbestus in Corsica; their mica in Spain.

Its modern uses are indicated in the following patents, and the enumeration is made at some length, as the subject has been but lately revived, and one interested can in no other way so readily reach the present state of the art, — to borrow the conventional phrase, which is as good as any other.

1. Safes, lining for: W. Marr, English, 1834. Hyatt, several patents, United States, 1869–70.
2. Lamp-wick: British patents: 2071 of 1853. 145 of 1857. 2647 of 1855. 1610 of 1863. Lord Cochrane, 1818.
3. Absorbent in lamps: Boyd, 1869. Beschke, 1866. in carburetors: Bassett, 1862.
4. Fire-brick and crucibles: Peters, 1862. English patent 2318 of 1862, asbestos, fire-clay, and graphite. Lewis, 1871. A covering of asbestus twisted into a rope and wound around a crucible.
5. Packing for hot-air engines: Lanbereau, 1859. for explosive engines: Drake, 1865. for steam-engines: Drake, 1865. combined with hair: Murphey, 1870. loose flock asbestus; Hoke.

6. Boiler covering: Peters, 1862.
Hardy, 1869. Selden and Kidd, 1865.
Murphy, 1870. Spencer, 1868.
Riley, 1871. French, 1869.
Murfey, 1870.
7. For forming a radiating surface, as in gas-stoves, fire-grates, and broilers.
8. In porcelain manufactures, of teeth especially, placed on the side of a muffle to isolate the biscuit from the slide, to prevent its becoming attached thereto in the process of baking.
9. As an anti-friction composition for journal-bearings, pistons, etc.
British patent, 2048 of 1858. Devlin, 1860.
Peters, 1862. Devlin, 1865.
Botticher: with soapstone and cotton, 1864.
Kelly: with graphite and iron-filings, 1870.
Johns: with caoutchouc, 1868.
10. For molded articles: Whitmarsh, 1868.
11. For roofing cement: Johns, 1868.
Kidwell, 1868. Moore, 1868.
12. Flooring cement: Whitmarsh, 1867.
13. Electric insulator: English patent, 362 of 1865.
14. In refrigerators: Hyatt, 1870.
15. In ink: Smilie, 1863.
16. For paper: English patent, 1413 of 1853.
Johns, 1868. Schaeffer on Paper, an old German book, describes asbestus paper, and contains a specimen.
17. For coffins — mixed with clay: 1870.
18. For ropes strengthened with other materials, Stevens, 1870 and 1871.
19. For yarn: separated into filaments by alkaline treatment, and then treated like wool: Rosenthal's patent, 1872.

As-bes'tus Stove. A stove heated by gas and having asbestus spread over the perforated pipes, in order to obtain an incandescent mass, which radiates heat, but does not consume.

Asbestus is used for lamp-wicks; as a filling for iron safes; for firemen's clothes; and in the laboratory as a wrapper for articles which are to be consumed to ashes. See ASBESTUS.

As-cend'ing Let'ter. (*Printing.*) Capital letters, and the small ones which rise above the line. They are *b, d, f, h, k, l.*

As'ci-a. (*Surgical.*) An axe-shaped bandage.

Ash'es E-jec'tor. An arrangement on board large steam-vessels to reduce the labor of hoisting out the ashes in buckets.

A chamber or tube is formed, rising from the stoke-holes, and opening above the water-line into the sea. By means of a jet of steam the ashes are directly driven from the engine-room into the sea, through the tube, the arrangement of which prevents the possibility of its being choked up. A similar method has also been adopted on stationary land-engines whose boilers are fixed below ground.

Ash'-fur-nace. A furnace in which the materials for glass-making are fritted.

Ash'lar; Ash'ler. (*Masonry.*) 1. (*a*) *Rough Ashlar;* a block of freestone as brought from the quarry.

(*b*) *Smooth Ashlar;* a block dressed ready for use.

(*c*) *Plane Ashlar;* a block in which the marks of the tool are dressed out.

(*d*) *Tooled Ashlar;* a block in which the surface has parallel vertical flutes.

(*e*) *Random-tooled Ashlar;* a block whose groovings are irregularly cut with a broad tool.

(*f*) *Chiseled Ashlar;* a random-tooled ashlar, wrought with a narrow chisel.

(*g*) *Boasted Ashlar;* same as chiseled.

(*h*) *Pick* or *Hammer-dressed;* it is known as *Common Ashlar.*

(*i*) *Bastard Ashlar* is ashlar-work backed up with inferior work.

(*j*) *Pointed Ashlar;* the face-marking done by a pointed tool or one very narrow.

(*k*) *Rusticated Ashlar;* the face of the block projects from the joint, the arrises being beveled. It may be rough or smooth-faced, or variously tooled.

(*l*) *Herring-bone Ashlar* has a tooling of oblique flutes in ranks running in alternate directions.

(*m*) *Nigged Ashlar;* a building-block dressed with a pointed hammer.

(*n*) *Prison Ashlar;* the surface is wrought into holes.

A smooth face around the joint is called a *margin-draft.*

The walls of the principal entrance of the gate at Thebes are at their base not less than 50 feet in thickness. The stones are squared on all sides, not merely on the external faces, and are built-in solid, no *rubble-work* being introduced to fill up the space between the facing walls.

The *face* of an ashlar is the front exposed surface when built into the wall.

Flanks; the sides.

Beds; upper and lower surfaces.

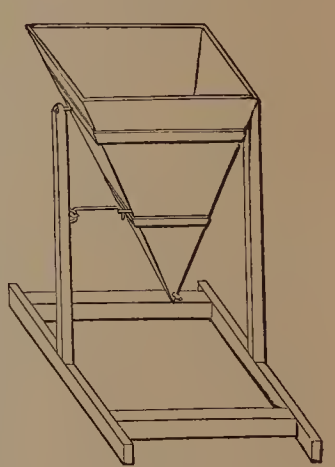
Back; rear surface.

2. (*Ashlar.*) A facing of squared stones or thin slabs used to cover walls of brick or rubble.

3. (*Carpentry.*) A vertical strut or quartering uniting the floor-joisting of the garret with the rafters above, forming the studding for the wall of the *half-story* room, cutting off an acute angle which may be utilized for closets.

Ash'-leach. A hopper in which ashes are placed while the soluble salts are removed by lixiviation. The leach is suspended upon journals which have bearings in the standards of the frame. The axis is at or about the center of gravity, so that the leach may be tipped to discharge its spent contents. A hook and staple hold it in operative position.

Fig. 387.



Ash-Leach.

Ash'ler-ing. (*Carpentry.*) Short upright pieces between the floor-beams and rafters in garrets for nailing the laths to. This cuts off the sharp angles between the floor and ceiling, giving a more convenient and tasteful appearance to the room. ASHLARING.

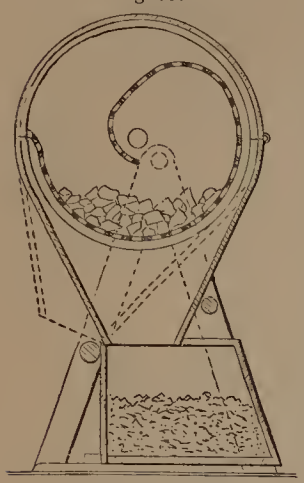
Ash'-pit. A cavity below the grate-bars of a furnace for receiving the ashes.

Ash'-plate. The back plate of a furnace.

Ash and Coal Sift'er. Sifters for coal are made on a large scale for mines, and are actuated by machinery, the object being to remove the dust which is unsuitable for ordinary stoves and furnaces. They consist of rotary wire-screens into which the coal is passed, or of a succession of inclined screens over which the coal passes by gravity, the jarring of the pieces assisting in keeping open the meshes of the screen.

For household use, as ash-sifters, they assume several forms, — rotary screens; reciprocating sieves

Fig. 388.

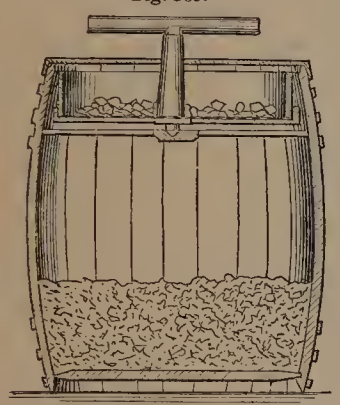


Rotary Sifter.

in boxes; oscillating sieves adapted to fit the tops of barrels; consecutive inclined sieves, which sort the material into grades; and sifters adapted to the ash-pits of stoves and furnaces.

In Fig. 388 the wire sieve is volute-shaped in transverse section, and its horizontal shaft revolves on bearings in a case. The lid of the latter opens to charge the sieve when its open mouth is presented upwardly, as in the cut. By revolving in one direction the contents are retained in the sieve, except the dust, which falls through the meshes. The operation completed, the sieve is revolved in the other direction, which discharges the larger contents into a receptacle placed to receive them.

Fig. 389.

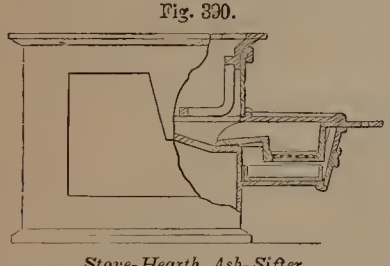


Ash-Sifter.

In Fig. 389 a central bearing is supported by radial arms inside the barrel, and supports the circular sieve which is oscillated above it. The central post of the sieve passes through a hole in the cover, and a cross-handle above affords the means of agitation.

The sifter for stove-hearths has a handle and a spout, and is placed below the hearth-plate in the ash-pit of the stove. Its office is to catch the ashes from the grate. It is vibratable in place, while the hearth-plate prevents the escape of dust. The finer portions fall into the pan below, and the contents of the sieve are thrown on the fire. There are over eighty patents on ash and coal sifters.

Fig. 390.



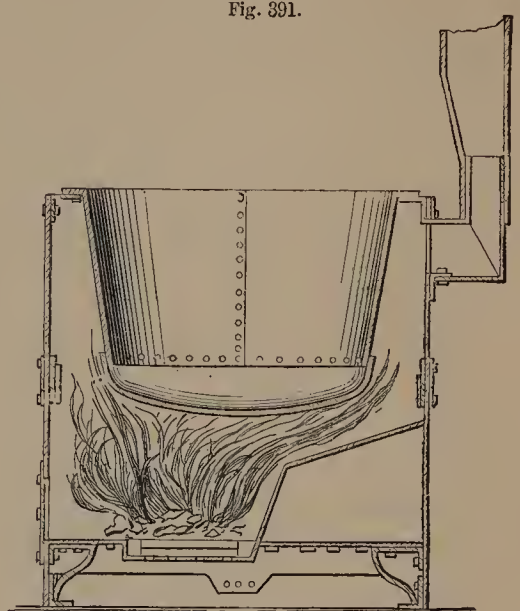
Stove-Hearth Ash-Sifter.

As-phalt' Pave'ment. As employed in Europe, this is prepared from a dark brown bituminous limestone which is found in the neighborhood of the Jura Mountains. This stone is reduced to powder, mixed with mineral tar and grit, and the whole exposed for several hours to a strong heat in large caldrons, being continually stirred until the ingredients are thoroughly united. The composition is then run into molds forming cakes about eighteen inches square and six inches thick, and weighing 125 or 130 pounds. The blocks are laid upon good, well-rammed foundations. They do not appear to stand the wear incident to a large city, but have been laid with advantage in corridors and as pavement in railroad stations in Europe. Various analogous compounds have been patented in the United States for paving and roofing. See PAVEMENT; ROOFING.

As-phal'tum Fur'nace. Asphaltum, or native bitumen, is largely used for pavements, roads, roofs, and as a water-proof cement. For pavements, etc., it is mixed with sand or gravel, and laid while hot upon a foundation of broken stones, pebbles, or gravel. The Seyssel Asphalt is a compound of a bituminous limestone, ground fine, heated, mixed with a small portion of tar, and considerable sand. The material is brought from the Jura Mountains, and, for a while, was very popular in Europe.

Beds of mineral pitch exist in many parts of the world, and are applied as fuel, to yield a liquid hydrocarbon, for paying woodwork, as cement, and, as has been said, for roofing, paving, etc. As it requires to be laid on while hot, a portable furnace (Fig. 420) is required, from whose boiler it is ladled

Fig. 391.



Asphaltum Furnace.

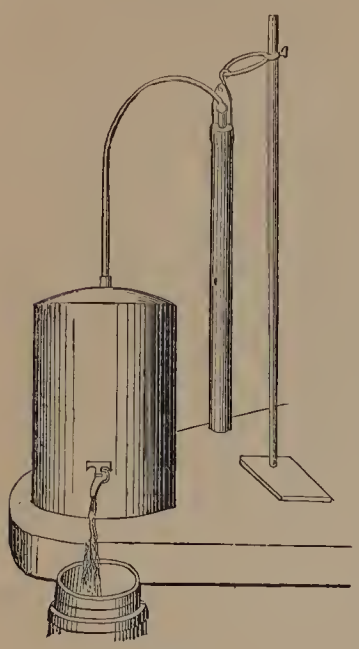
out and spread in its warm, plastic condition upon the surface to be treated.

A number of formulas for compounding the material will be given under ROOFING (which see).

In laying pavement, the thickness of the asphaltum is regulated by strips of wood, dividing the space into transverse sections. The material is spread by the shovel or a wooden spatula, and the surface beveled by a floating rule which rests upon the upper edge of the strips. Slate dust, fine sand, plaster of Paris, etc., may be dusted upon the top.

As'pi-ra'tor. An apparatus for passing a regulated supply of air in contact with a contrivance which determines its chemical character or its condition, hygrometric or otherwise; or for passing given quantities of air in contact with a substance whose changes are the subject of observation. A jar filled with water is provided with a cock, by which the water is allowed to escape at a given rate. The space in the jar, above the water, is connected by a flexible pipe with the duct in which the chemical ingredients are placed or with the hygrometer chamber. The uses are various, and will readily occur to the expert, in connection with the quantitative admission of air or gases to chemical solutions.

Fig 392.

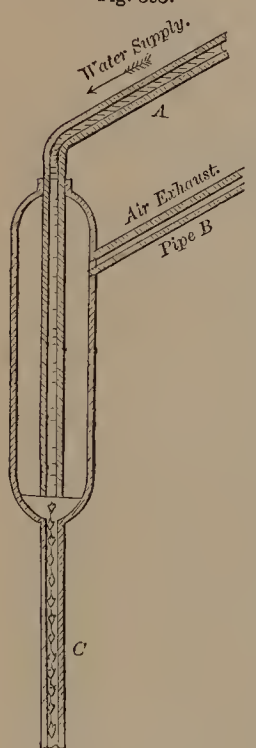


Aspirator.

ignited tapers, or organic matters. The measure of the water which has flowed from the jar is of course coincident with the air which has taken its place.

The use of the aspirator is recommended in the healing of great amputations, by Maisonneuve, Surgeon of the Hôtel Dieu, Paris. The liquids exuding from the surface of the wound coming in contact with the air, poisonous putrefaction ensues; to arrest this action, Dr. Maisonneuve, after dressing the wound with lint saturated with antiseptic liquids, brings into use an aspiratory apparatus which withdraws the contaminated air from the presence of the wound.

Fig. 393.



Sprengel's Aspirator.

A form of aspirator invented by Sprengel is now much used in the laboratories in Europe, especially in expediting filtering. The water from a reservoir passes in by the supply-pipe *A*, and drops into the discharge-pipe *C*, carrying with it a pellicle of air; this is repeated in quick succession, and the effect is to withdraw air by the pipe *B*, from the chamber with which the said pipe is connected. The discharge-pipe *C* is 30 feet long. The vacuum attained is said to be as high as 29 inches of mercury.

Sprengel used mercury, which permits a discharge-pipe of say three feet in length. Bunsen lengthened the pipe and used water.

Guerin's apparatus for this purpose consists of a hemispherical balloon provided with three tubulatures, the central and largest one being fitted with a manometer of very simple construction, a graduated glass tube terminated by an india-rubber ball filled with mercury. The ball is inclosed in the balloon, so that in proportion to the vacuum effected in the latter the former is dilated, in consequence of which the mercury in the tube falls, a scale showing the amount of fall, and hence also the degree of rarefaction in the balloon. The second tubulature receives a tube communicating with the receiver of an air-pump; and by a third, communication is effected between the balloon and each patient or hospital bed by means of india-rubber tubes, so that "pneumatic occlusion," as it is called, may be extended simultaneously to all the patients confined in the same surgical ward. There are stop-cocks for regulating the degree of vacuum in the central vessel, and the part under treatment is covered with a sort of india-rubber hood which protects it in each case from the action of the external air.

Aspirators are also used to prevent the heating of grain in bulk, by causing a constant circulation of air through its mass.

The aspirator, substantially as shown in Fig. 393, is used in maintaining a partial vacuum in the condensers of steam-engines, vacuum-pans, etc., where a discharge-pipe of 30 feet perpendicular length can be obtained.

The aspirator is also used in picking up pieces or sheets of paper, for feeding into paper-folding or envelope machines.

As-pir'ing Pump. 1. A pump in which the mechanical action is due to the forcible ejection of air from the lungs. A suction-pump.

2. A pump used to draw air from a chamber or vessel. See ASPIRATOR.

Ass. (*Paper-Making.*) A post in the bridge of a pulp-vat to lay the mold upon while the water drains from it. Used in the hand-made paper work.

As-say'. An operation for testing the proportion of any metal in an ore or alloy.

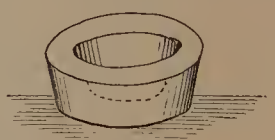
There are several modes of procedure: —

1. By specific gravity.
2. By the touchstone.
3. The wet method, — by liquid solvents.
4. The dry method, — by fluxes and fire.

As-say' Bal'ance. A delicate balance used in assaying. See BALANCE.

As-say' Fur'nace. A furnace with a chamber or muffle in which the metal is exposed to heat.

Fig. 394.

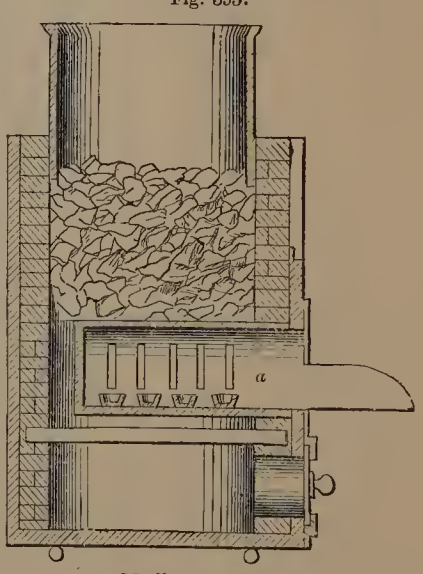


Cupel.

The furnaces used for cupellation differ considerably in shape and mode of construction: one form is represented in Fig. 395.

The muffle *a* is an oven-shaped vessel made of baked fire-clay, closed at one end and open at the other, and generally having also openings in its sides and top; its inner closed extremity usually rests on a ledge or shelf in the furnace, and its open end is luted to the entrance of the furnace, and has before it a small platform on which the hot cupels (shown on an enlarged scale in Fig. 394) can

Fig. 395.



Muffle and Furnace.

stand when withdrawn from it. In this position it can be equally heated in every part, while the apertures in the sides and top allow a current of air to pass through its interior and into the furnace itself.

As-se-gai'. A light projectile spear employed by the Kaffirs.

As-sem'bling. By assembling is understood the act of putting in their respective places and fastening together the component parts of an article composed of a number of distinct pieces, so as to form a complete and perfect whole; as, the cheeks and stock of a gun-carriage, with their connected parts; the lock, stock, and barrel of a musket, etc.

The term is more peculiarly applicable to the fitting together parts which are made strictly to fixed shapes and dimensions so as to be promiscuously interchangeable.

The system of interchangeability of parts was first introduced into the French Artillery service by General Gribeauval, about the year 1765.

Previous to this time each part of a gun-carriage was made specially for that carriage alone, and could not be used for repairing any other, unless after extensive alterations. Gribeauval simplified the system, or rather want of system, then in vogue, by reducing the carriages into classes, and so arranging many of the parts that they could be applied indiscriminately to all carriages of the class for which they were made. This system was farther simplified and extended, and was finally applied in the United States arsenals and armories to all articles made up of pieces, the improvements in machinery enabling most articles to be made accurately to pattern without depending on the eye and hand of the workman. This has been carried to a very high pitch of improvement by means of the machinery at the Colt's arms factory and other manufactories of small-arms in this country; and the beauty and utility of the system, by which exact equality of dimensions is insured in every one among thousands of almost microscopic screws and other small parts, are particularly exemplified in the work of the American watch and sewing-machine companies.

This system of interchangeability and assemblage, which by enabling a large proportion of perfect and serviceable articles to be made up from the parts of similar articles which have been broken or injured in use, instead of permitting them to be cast into the scrap-heap, is one of the most beautiful triumphs of modern mechanism.

It has proved itself capable of adaptation to large as well as small machinery, and is now applied to the locomotives of the Pennsylvania Central Railroad, whose parts are made interchangeable.

The first notice in this country of this excellent mode of manufacturing a number of articles designed to be exactly similar, is the breech-loading rifle of John H. Hall, of North Yarmouth, Massachusetts, patented May 21, 1811, and which he refers to in the following terms in a letter to the War Department: "Only one point now remains to bring the rifles to the utmost perfection, which I shall attempt if the government contracts with me for the guns to any considerable amount, namely, to make every similar part of every gun so much alike that it will suit every gun, so that if 1,000 guns are taken apart and the limbs thrown promiscuously together in one heap, they may be taken promiscuously from the heap and will all come right."

In 1816, 100 of these arms were made; 2,000, in 1827. In 1836 Congress voted $10,000 to Hall, being at the rate of one dollar per arm for all made on his principle to date.

As-sem'bling Bolt. One used for holding together two or more removable pieces, as the checks and stock of a field gun-carriage.

As-sis'tant En'gine. An accessory locomotive, to assist the ordinary train engine in ascending heavy grades.

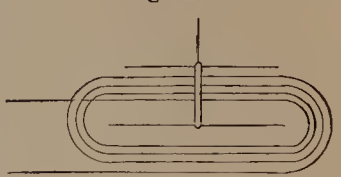
A donkey engine. A small engine used in operating a large one for moving the lever, or carrying the fly-wheel over a dead-center.

As-size'. A layer of stone, or one of the cylindrical blocks in a column. The number of *assizes* in the Great Pyramid was 203 (Kenrick). Several have been removed from the apex, which now presents a platform of 25 feet square. The *assizes* vary from two feet two inches to four feet ten inches in depth. From five to twelve feet is the common length of the stones, except in the king's chamber.

A column is said to be *monolithic*, or else to consist of *assizes*.

A-stat'ic Nee'dle. A magnetized needle whose polarity is balanced so as to remove its tendency to assume any given direction.

Fig. 396.



Astatic Needle.

It was in 1820 that Oersted, of Copenhagen, announced that the conducting wire of a voltaic circuit acts upon the magnetic needle, and thus recalled into activity that endeavor to connect magnetism with electricity which, though apparently on many accounts so hopeful, had hitherto been attended with no success. Oersted found that the needle has a tendency to place itself at right angles to the wire, a kind of action altogether different from any which had been suspected.

If two similar magnetized needles are placed parallel, but with their poles turned in opposite directions, and are suspended by a thread without twist so as to move freely, they have little tendency to place themselves in the magnetic meridian.

The action of terrestrial magnetism upon one needle neutralizes its action upon the other, and consequently the needles remain indifferent. A needle of this description is called *astatic*, and is used in the construction of the *astatic galvanometer*.

If one of the needles be placed in a coil of wire excited by an electric current, on the passage of the current the needle is deflected; and its deflections are more considerable than those of a simple needle, because there is, in the first place, but little resistance to overcome, and secondly, because the current acts upon two needles instead of one, the upper needle being deflected in the same direction as the lower.

As'tel. (*Mining.*) Overhead boarding or arching in a gallery.

As-tig'ma-tism Ap-pa-ra'tus. (*Optics.*) An instrument for detecting the presence and amount of the defect in vision arising from a certain want of symmetry in the lens or cornea.

It may consist of two revolving rings divided to 5°, each ring being furnished with springs to hold a cylindrical glass; a diaphragm fitting in one ring, and a movable slit in the other. The object is to test whether the eye has greater power to detect distinct separation between closely ruled lines in a vertical, or horizontal, or intermediate position.

As'tra-gal. (*Carpentry.*) *a.* A small molding of a semicircular section with a fillet beneath it.

b. One of the rabbeted bars which hold the panes of a window. The *astragals* of the lanterns in the

Stevenson lighthouses are diagonal, so as not to intercept the light in the azimuth which they subtend.

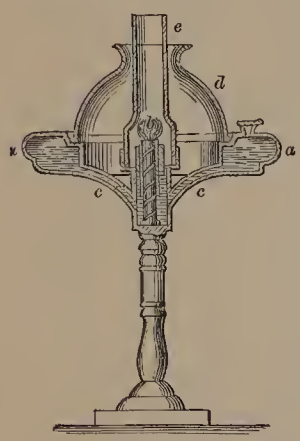
(*Ordnance.*) An outwardly curved molding. The astragal of a cannon is the molding at the front end of the chase.

As'tra-gal Plane. (*Joinery.*) A bench plane adapted for cutting astragal moldings.

As'tra-gal Tool. A wood-turning chisel having a semicircular concave face, for turning beads and astragals.

As'tral Lamp. A lamp with an annular oil reservoir connecting by two pipes with the wick tube, the latter being on the summit of the pedestal. It is designed to obviate the interception of light by the oil reservoir, which when placed centrally casts a shade upon the table.

Fig. 397.



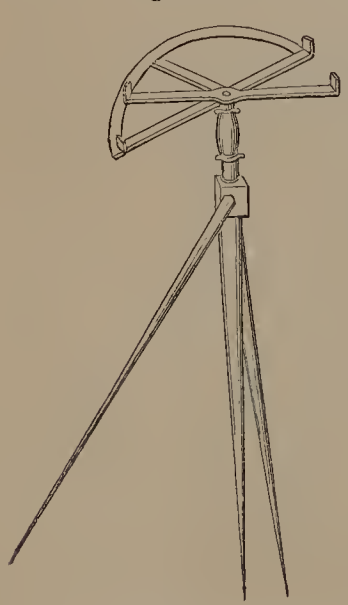
Astral Lamp.

In the arrangement shown at Fig. 397 the oil is contained in the annular chamber *a* surrounding the burner *b*, which is of the Argand kind (see ARGAND), and the lower part of the chimney, and thence descends to the foot of the wick through the two tubes *c c*.

It will be seen that the downward rays of light from the burner are not at all intercepted in the immediate vicinity of the lamp, except by the two small oil pipes, and that they are not materially interfered with, within a radius beyond which the light would be insufficient for reading or working by; even this is obviated in a considerable degree by the ground-glass globe *d* surmounting the annulus, which diffuses and equalizes that part of the light which is not cast downward. The chimney *e* assists combustion, and carries off the volatile products thereof.

As'tro-labe. The common astrolabe (not the astrolabe of Hipparchus, used in determining the altitudes of the stars) is used for measuring angles. It is graduated to degrees, and sometimes to quarter-degrees. A strip is attached in the direction of the diameter, passing through 0° and 180°, and has a tongue by which it is placed centrally upon the stand. This strip has two fixed diopters or sight-vanes. Another strip turns about the center, one end of which in the half-astrolabe (both ends in the full astrolabe) traverses the graduated limb and carries other sight-vanes. The middle line of this alidade coincides with the axis of the sight-vanes and the center, and is marked upon the beveled edge of the alidade as an index. The diopters are both ocular and objective, for fore and back sighting. A small compass may be attached at the center, and the tongue fitted up with nut and screw so as to permit the circle to be brought from the horizontal to the vertical position for the purpose of measuring altitudes.

Fig. 398.



Astrolabe.

To measure an angle with the astrolabe, the latter is placed with its center over the vertex of the angle, and turned until the fixed diopters sight in the direction of one side. The movable strip with its diopters is then sighted in the direction of the other side, and the angle contained between the two strips is read off. Telescopes may be attached in place of the alidades. Thus arranged, it becomes allied to the theodolite.

Tycho Brahe's *Astronomice Instauratæ Mechanica* gives several cuts of astrolabes. The astrolabes of Hipparchus, Ptolemy, Alhazen, and Tycho Brahe did not agree in all particulars of construction. They have been superseded by more improved instruments.

The astrolabe was invented to ascertain the position of the sun with regard to the ecliptic. (Whewell.) The instrument as described by Ptolemy consisted of circular rims, movable one within the other, or about poles; and contained circles which were to be brought into the position of the ecliptic, and of a plane passing through the sun and the poles of the ecliptic. See ARMILLARY SPHERE.

The *astrolabon* which Martin Behaim attached to the main-mast belongs originally to Hipparchus. When Vasco de Gama landed on the east coast of Africa, he found the Indian pilots at Melind acquainted with the use of astrolabes and cross-staffs.

As-trom'a-ra. A concave representation of the heavens.

As-trom'e-ter. An instrument invented by Sir John Herschel for comparing the intensities of light of the stars one with another by the intervention of a natural standard, such as the moon or the planet Jupiter, brighter than any of the stars to be compared, and giving an amount of light which, if not absolutely invariable, varies in such a manner that its changes are susceptible of calculation. Jupiter, being sufficiently bright, and his light being increased or diminished only in proportion to his distance from the sun, is considered as well adapted for the purpose.

The process, as described by Sir John, "consists in deflecting the light of the moon by total internal reflection at the base of a prism so as to emerge in a direction exactly coincident with that of the undeflected light of one of the stars to be compared. It is then received upon a lens of short focus, by which the image of the moon is formed, which, viewed at a considerable distance by an observer placed in or near the axis of the lens, will appear to him as a star. This artificial star is then approached to or removed from the eye until its light is judged to be exactly equal to that of the real star, which lying in nearly the same direction from the observer will be seen side by side with the artificial one by the same eye, or with both eyes at once without the aid of a telescope, as in the ordinary mode of natural vision. The distance of the eye from the focus of the lens being then measured, the prism and lens are to be placed so as to form another similar artificial star in a direction nearly coincident with that of the other star under comparison; and, another equalization being made and distance measured, it is obvious

that the intensity of the lights of the two stars, or at least their effects on the retina under the circumstances of comparison, will be to each other in the inverse ratio of the distances so measured respectively."

The term "astrometer" has been also applied to an object-glass micrometer, as well as to an instrument for finding the rising and setting of stars and their positions.

As-tro-nom'i cal Clock. A clock regulated to keep regular time; *sidereal*, not *mean*.

As-tro-nom'i-cal In'stru-ments. The first phenomenon recorded in the Chinese annals is a conjunction of five planets in the reign of Tchuen-hiu (2514 – 2436 B. C.). The record is verified by Fr. de Mailla and others, and identified with 2461 B. C. Saturn, Jupiter, Mars, and Venus were, with the moon, comprised within an arc of about 12° in the constellation Pisces. The emperor Yao, 2357 B. C., determined the length of the moon's year.

An orrery is said to have been constructed in the second century A. D. in China; the account states that it represented the apparent motion of the heavenly bodies round the earth, and was kept in motion by water dropping from a clepsydra.

The heliocentric, the true theory of our solar system, was taught in Ancient Egypt, and there Pythagoras learned it. This great philosopher perceived its truth, and carried it to Asia Minor, where it languished and died. The Egyptian race were originally emigrants from Asia, probably Arabians, and may have brought their astronomical knowledge with them. It is also possible that the Chaldees were participants in the true theory many ages before Greek explorers touched the borders of the Mesopotamian nations.

Eratosthenes of Cyrene, the Alexandrian astronomer, set on foot the first Hellenic measurement of an arc of the meridian, having its extremities at Alexandria and Syene, and for its object the approximate measurement of the earth's circumference. The measurement was the paces of pedestrians, but is interesting as among the earliest recorded instances of this broad generalization, where a philosopher rose from the consideration of the narrow limits of a single country to the knowledge of the magnitude of the entire globe. A more ancient Chaldean measurement is mentioned, the count being obtained in camels' paces, 4,000 paces to the mile, 33⅓ miles to half a degree, — circumference of the earth, 24,000 miles. See *Comptes Rendus*, T. XXIII. p. 851, 1846.

Another measurement of a degree of the meridian was made under the orders of the Khalif Al-Mamun in the great plain of Sinds-char, between Tadmor and Rakka, by observers whose names have been preserved to us by Ebn Junis, tenth century.

"Each sage went for what he wanted to the proper mart of science: for not only Pythagoras studied astronomy at Heliopolis, where it was professed with the greatest *éclat;* but Eudoxus got his geometry at Memphis, whose priests were the most profound mathematicians; and Solon was instructed in civil wisdom at Sais, whose patron deity being Minerva (as we are told by Herodotus and Strabo), shows politics to have been there in most request."— WARBURTON'S "Divine Legation of Moses," Vol. I. Book II., ed. 1742.

The earliest observations in Babylon were 2234 B. C. Of their instruments we have no record: dials and zodiacal circles probably. The invention of the zodiac is by many experts credited to the Egyptians, and the reasons cited are entitled to high consideration. It is of high antiquity, and if pre-Egyptian was derived from the Orientals. Mazzaroth, cited in Job xxxviii. 31, 32, probably referred to zodiacal division.

One of the earliest instruments on record is that in the Memnonium, the great palace of Rameses II. It consisted of a golden zodiac or circle on which were engraved the days of the year, with the heliacal rising and setting of the stars by which each day was known. This golden planisphere was placed immediately over the sepulchre, upon a base 365 cubits (547½ feet) in circumference, or about 182 feet in diameter, and one cubit in thickness. It was divided and marked at every cubit with the days of the year, the rising and setting of the stars according to their natural revolutions, and the signs ascertained from them by Egyptian astrologers.

Rameses reigned in the fourteenth century B. C., — the century after the settling of the land of Canaan by Joshua and the century before the Argonautic Expedition. The golden circle was carried away by Cambyses when he plundered Egypt, 525 B. C., about the time of Kung-fu-tze (Confucius).

Ptolemy Euergetes, 246 B. C., placed in the square porch of the Alexandrian Museum an equinoctial and a solstitial armil, the graduated limbs of these instruments being divided into degrees and sixths. There were in the observatory stone structures, the precursors of our mural quadrants. On the floor a meridian line was drawn for the adjustment of the instruments. There were also astrolabes and dioptras. The above were used from 246 B. C. to A. D. 417, and similar instruments at Cordova, A. D. 1000. Tubes with sights were probably used at both places; lenses being added in 1608.

See articles under the following headings: —

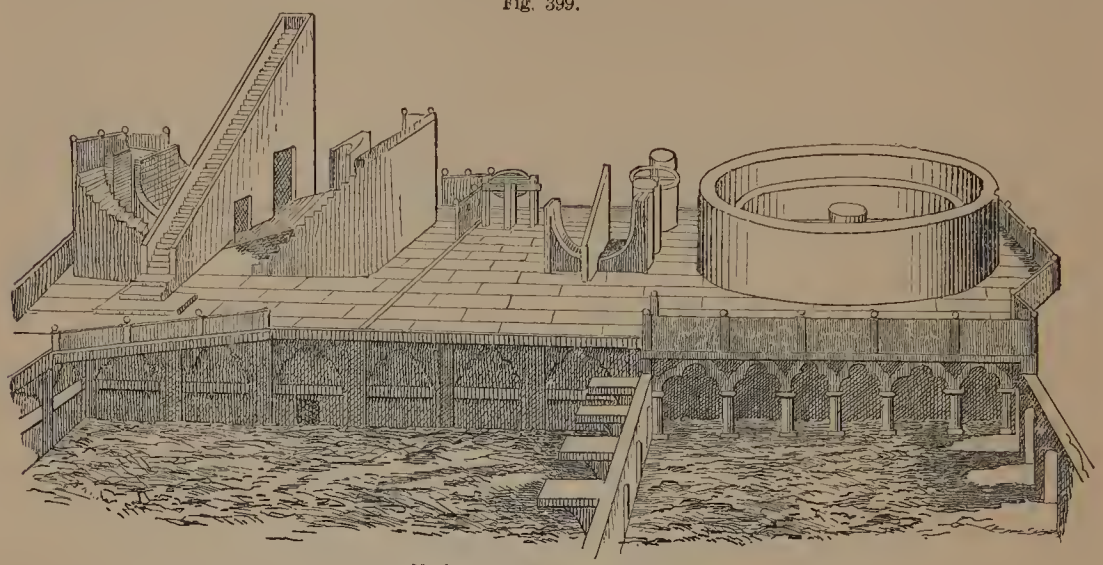
Altarimeter.
Apomecometer.
Armil.
Armillary Sphere.
Artificial Horizon.
Astrolabe.
Astrometer.
Astroscope.
Azimuth Circle.
Azimuth Dial.
Back-staff.
Collimator.
Comet-Seeker.
Compass.
Cosmolabe.
Dipleidoscope.
Dip Sector.
Equatorial Teleseope.
Finder.
Heliometer.
Meridian Circle.
Micrometer.
Mural Circle.
Optical Instruments.
Orbit-Sweeper.
Orrery.
Planetarium.
Reflecting Circle.
Refraction Circle.
Telescope.
Tellurian.
Transit.
Universal Instrument.
Zenith Sector.
Zenith Tube.

In Europe, the Arabs were the first to build observatories; the Giralda, or Tower of Seville, was erected under the superintendence of Geber the mathematician, about A. D. 1196, for that purpose. After the expulsion of the Moors it was turned into a belfry, the Spaniards not knowing what else to do with it. The same people mistook the vertical gnomons of Quito — beneath the line — for idols, and upset them, crossing themselves devoutly. Of the obelisks of Egypt, the round towers of Ireland, and the gnomons of Quito, the last is the least distinctly phallic.

The native observatory at Benares, India, is an elevated terrace, and will afford us a good idea of the probable appearance of the observatories of Ancient Chaldea; of the Caliph Almanza; of Ulug Beg, grandson of the great Tamerlane. The latter is said to have had a quadrant as high as the Church of Saneta Sophia at Constantinople.

Sir Robert Barker's description of the observatory

Fig. 399.



Native Observatory at Benares.

of Benares is as follows: "We entered this building, and went up a staircase to the top part of it near the river Ganges, that led to a large terrace, where to my surprise and satisfaction, I saw a number of instruments yet remaining in the best preservation, stupendously large, immovable from the spot, and built of stone, some of them being upwards of twenty feet in hight; and though they were said to have been erected many hundred years before, the graduations and divisions of the several arcs appeared as well cut and accurately divided as if they had been the performance of a modern artist. The execution in the construction of these instruments exhibited a mathematical exactness in the fixing, bearing, and fitting of the several parts, in the necessary and sufficient supports to the very large stones that compose them, and in joining and fastening them into each other by means of lead and iron cramps. The situation of the two large quadrants, whose radius is nine feet two inches, by being at right angles with a gnomon at twenty-five degrees elevation, are thrown into such an oblique situation as to render them the most difficult, not only to construct of such a magnitude, but to secure in the position for so long a period, and affords a striking instance of the ability of the architect in their construction; for, by the shadow of the gnomon thrown on the quadrants, they do not appear to have altered in the least from their original position; and so true is the line of the gnomon, that, by applying the eye to a small iron ring of an inch diameter at one end, the sight is carried through three others of the same dimensions, at the extremity of the other end, distant thirty-eight feet eight inches, without obstruction."

The earliest modern observatory of importance in Europe was erected by the landgrave of Hesse Cassel in 1561. It occupied the whole upper portion of his palace, and was well furnished with astronomical instruments. Tycho Brahe, about the same period, made material improvements on the landgrave's instruments, and constructed a quadrant capable of showing single minutes. He afterwards erected an observatory on the island of Huen, under the patronage of the king of Denmark; it was furnished with quadrants, sextants, circles, astrolabes, globes, clocks, and sun-dials. These instruments were divided to single minutes, and some were so divided as to read to ten seconds.

The royal observatory at Paris was completed in 1671, and was placed in charge of M. Cassini, after having been furnished with instruments at a very great expense.

The Greenwich Observatory was erected five years later; Flamstead, under the title of Astronomer Royal, was its first superintendent.

The Yale College Observatory was started in 1828, a donation made by Mr. Clark being expended in buying a telescope of Mr. Dollond of London. It has a focal length of ten feet, and five inches aperture.

The Williams College Observatory was the first regularly constituted observatory in the United States, 1836. It has a Herschelian reflector of ten feet focus, mounted equatorially; also a transit instrument and compensation-clock.

The Hudson Observatory of the Western Reserve College, Ohio, was built and furnished in 1838, having an equatorial, transit, and clock.

The High School Observatory of Philadelphia was furnished in 1840.

The West Point Observatory about 1841.

The Tuscaloosa Observatory in 1843.

The Washington Observatory about 1844.

The Georgetown, D. C., Observatory in 1844.

The Cincinnati Observatory in 1845.

The Cambridge Observatory in 1847.

The Amherst Observatory in 1847.

Dartmouth, Newark, Shelbyville, Ky., Buffalo, Michigan University, Albany, and Hamilton College, have also observatories.

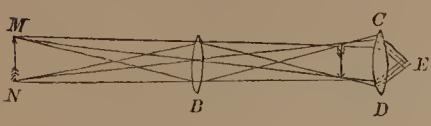
A good article on the astronomical observatories of the United States may be found in Harper's Magazine, June, 1856. See also "Observations at the Washington Observatory," volume for 1845.

For more full details than in the articles named, see Chambers's Astronomy; Dr. Pearson's Practical Astronomy; Loomis's Practical Astronomy; Simm's Treatise on Instruments; Heather on Mathematical Instruments.

As-tro-nom'i-cal Lan'tern. One with panes or slides having perforations whose relative size and position represent stars in a given field of the heavens.

As-tro-nom'i-cal Tel'e-scope. A telescope in which the image is inverted, composed of a converging object-glass *A B*, and of a converging eye-glass *C D*. Rays of light falling from any point *M* of a

Fig 400.



Astronomical Telescope.

distant object *M N*, and falling on the whole surface of the object-glass are refracted into the upper point in the principal focus. In like manner those proceeding from the point *N* are refracted into the lower point, and thus an inverted image is formed at the focus of the object-glass. The eye-glass is placed so that its focus shall coincide with the place of the image, consequently rays diverging from any point on the image, and falling on the lens *C D*, are rendered parallel and enter the eye at *E*, where they produce distinct vision.

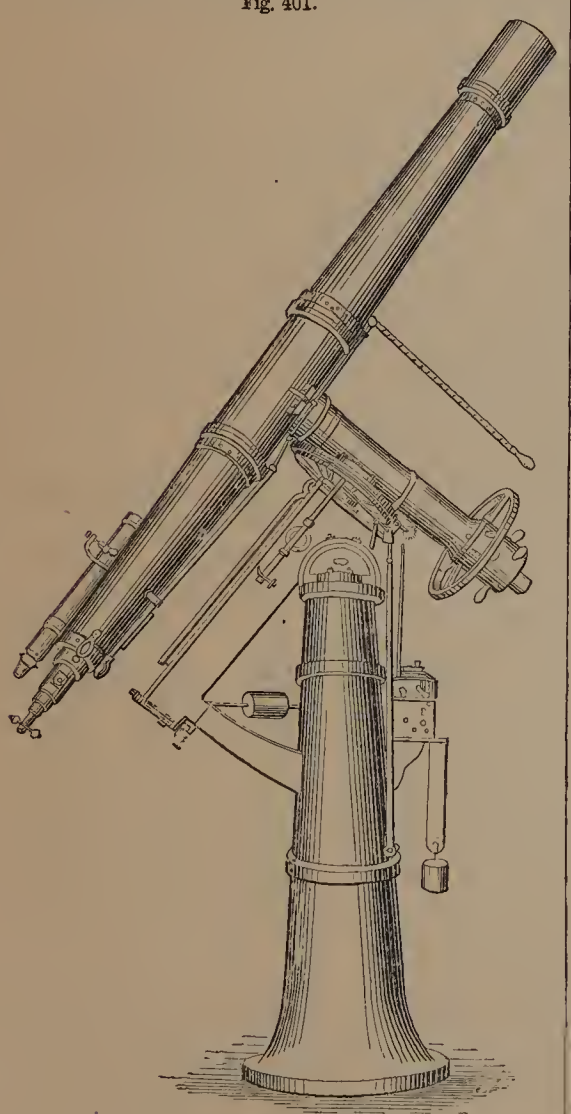
The length of the telescope is equal to the sum of the focal distances of the two lenses, and the magnifying power is equal to the focal length of the object-glass divided by the focal length of the eye-glass.

This telescope was first described by Kepler in his *Dioptrice*, 1611, but does not appear to have been executed till 20 or 30 years later.

A large instrument of its class was mounted at York, England, by Cooke. See Fig. 401.

It is mounted equatorially on the German princi-

Fig. 401.



Cooke's Telescope.

ple, having a finder at the side, as is usual with that class of instruments. Sidereal motion is communicated to the instrument by clock-work. Its object-glass is 25 inches in diameter.

The new refracting instrument for the Naval Observatory of Washington, D. C., is being made by Alvan Clark, of Cambridgeport, Mass., and will probably be completed during the present year (1873). Its object-glass is complete, and has a diameter of 27 inches. It is the largest of its class, and great hopes are reasonably entertained of its performances.

Large telescopes, equatorially mounted, are in the observatories of Cambridge, Eng., Cambridge, U. S., Chicago, Albany, Alleghany, and Pulkowa, Russia. The equatorial of Melbourne, Australia, is a reflector. See TELESCOPE.

As'tro-scope. 1. An astronomical instrument composed of two cones, on whose surfaces the constellations, with their stars, are delineated, and by means of which the stars may be known; an imperfect substitute for the celestial globe. — WEBSTER.

2. An astronomical instrument provided with telescopes, for observing the stars, invented and described by William Shukhard, of Tubingen, in 1698.

As-tyl'len. (*Mining.*) A small dam in an adit or mine to prevent the full passage of the water.

At-a'bal. A Moorish musical instrument resembling a tabor. — CROLY.

At-a-rim'e-ter. A philosophical instrument used in a fixed observatory.

Ath'a-nor. The original *Base-Burning Furnace.* It was used by the old alchemists to ensure a constant supply of fuel to a furnace intended to keep up a continued heat for many consecutive days.

Alongside the furnace-chamber was a hollow tower containing charcoal, and fitted with a close cover to prevent the passage of air. The lower part communicated with the fireplace, and as the contents of the latter burned away, the fuel from the tower subsided into the fireplace and kept up the fire.

The subject has been amplified of late years. Watt introduced it into his steam-boiler furnace about 1767. Many stoves are now constructed on that principle in England and in the United States.

At what time the venerable alchemists first contrived the athanor we do not know. We presume that Hermes Trismegistus, Aristotle, and their colaborers of Egypt and Rome, may have done without it, but that it may have arisen when Roger Bacon, Albertus Magnus, Paracelsus, Raymond Lully, and Basil Valentine set about the search. This latter scope embraces several hundred years of valuable services.

The supply-chamber is termed a MAGAZINE (which see). See also SMOKE-CONSUMING FURNACE; STOVE, BASE-BURNING; COOKING-STOVE, BASE-BURNING.

At'las. 1. A size of drawing paper measuring 33 × 26 inches, and weighing 100 pounds to the ream.

2. The Indian satin of commerce.

3. (*Architecture.*) Plural, *Atlantes.* Male human figures serving as pillars; called also Telamones. The name is derived from an intended resemblance to Atlas or Ajax. A somewhat different style of figures, in which the attitude exhibits the appearance of less violent exertion, are called Persians.

Female figures employed for the like purpose are termed Caryatides.

At-mi-dom'e-ter. Babington's atmidometer for measuring the evaporation from water, ice, or snow, consists of an oblong hollow bulb of glass or copper, communicating by a contracted neck with a globular bulb beneath, weighted with mercury or shot. The upper bulb is surmounted by a glass or metallic stem graduated to grains and fractions, on the top of which is a light shallow metal pan.

For use, the instrument is placed in a vessel of water having a cover with a circular hole in it through which the stem protrudes.

Distilled water is poured into the pan on top until the zero on the stem is brought down to the level of the cover of the vessel in which the instrument floats. As the water in the pan evaporates the stem rises, and the amount of evaporation in grains and parts is indicated by the scale.

An adjustment for temperature accompanies the instrument. — BRANDE.

At-mom'e-ter. An instrument to measure vaporous exhalations. An *evaporometer* or *hygroscope*.

It was invented by Professor Leslie for determining the rate of evaporation from a humid surface in a given time.

A thin ball of porous earthenware, two or three inches in diameter, with a small neck, has cemented to it a long and rather wide tube of glass bearing divisions, each of them corresponding to an internal section equal to a film of liquid that would cover the outer surface of the ball to the thickness of one thousandth of an inch. The divisions are ascertained by calculation, and are numbered downward to the extent of 100 to 200. To the top of this tube is fitted a brass cap, having a collar of leather, and which, after the cavity has been filled with distilled water, is secured tightly. The outside of the ball being now wiped dry, the instrument is suspended out-of-doors to the free action of the air. The quantity of evaporation from a wet ball is the same as from a circle having twice the diameter of the sphere. In the atmometer the humidity transudes through the porous surface just as fast as it evaporates from the external surface, and this waste is measured by the descent of the water in the stem. As the process goes on, a corresponding portion of air is introduced into the ball and rises into the tube.

A modified form of the atmometer consists of a vessel of porous earthenware, having a given area of surface and filled with water, poised at the end of a balance, and the loss in a given time noted by weights on the other end.

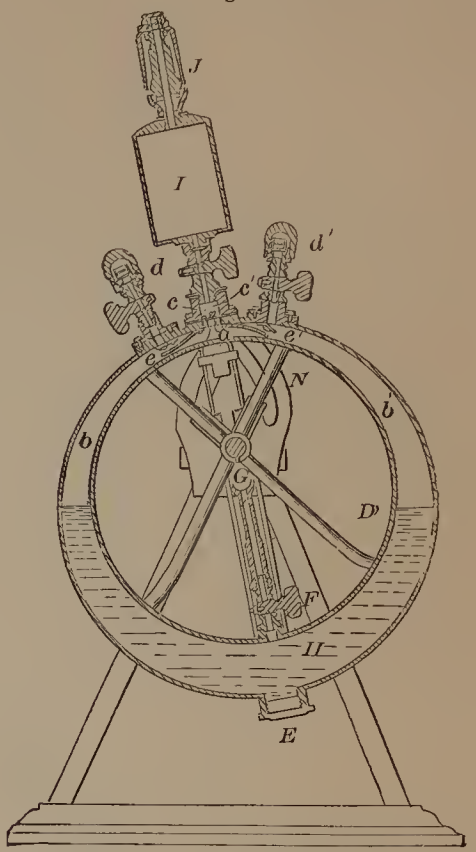
A thermometer inserted into the vessel will indicate the temperature of the evaporating liquid, and would form a *hygrometer* on the principle that the degree of cold generated by evaporation is proportional to the dryness of the air.

At-mos-pher'ic Alarm'-Whis'tle. A whistle blown by the air. It is principally used as a nautical alarm, being attached to a buoy, or placed on a pile or floating vessel, to warn ships from a shoal or spit of land. It is to be distinguished from audible alarms produced by clock-work or other machinery by which a blast of air is impelled through a whistle or horn. These are considered under FOG-ALARM; NAUTICAL ALARM; which see.

CABELL'S Atmospheric Alarm-Whistle, 1867, is sounded by the alternate eduction and induction of air from or into an annular chamber, which is partially filled with water and oscillated by the motion of the vessel, assisted by other power, if necessary. The motion may be made to work an air-pump to increase the energy of the blast, or its effectiveness may be augmented by gas, generated by chemical action in the chamber.

The chamber *D* has air-spaces *b b'* communicating by valves *c c'*, on either side of the dividing plate *a*, with the blast-whistle *J*. *d d'* are vacuum whistles, which act alternately as the chamber sways in one direction and the other, supplying air to that side of the chamber which is abandoned by the water. The funnel *G* is the means of supplying the chamber *D* with water. Oil upon the surface of the water in

Fig. 402.



Cabell's Atmospheric Alarm-Whistle.

chambers *b b'* prevents evaporation. *e e'* are valves to the vacuum-whistle ports. *I* is an air-chamber.

At-mos-pher'ic Churn. A churn in which atmospheric air is driven into the milk in order to agitate it, and also to obtain the specific effect of the air upon the milk in aggregation of the oleaginous globules.

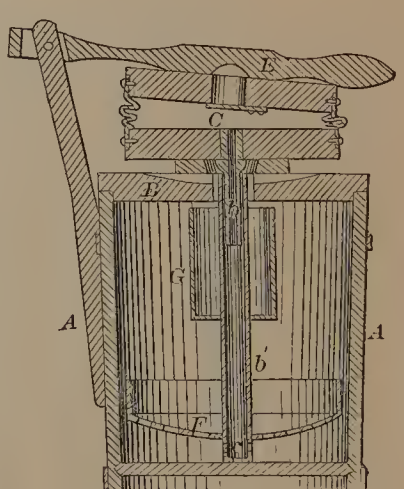
There are many modes of doing this: —

1. The *air-pump*.

In this case the air is driven by mechanical means into and through the milk by means of a piston working in a cylinder, or by a bellows.

In the example (Fig. 403) the air is driven by the bellows *C* through the pipes *b b'*, passes out at *c*, and is distributed through the milk by the perforated diaphragm *F*. *G* is a vessel in which hot or cold water may be placed to temper the milk. The bellows-handle *E* is supported by a post on the churn *A*.

Fig. 403.

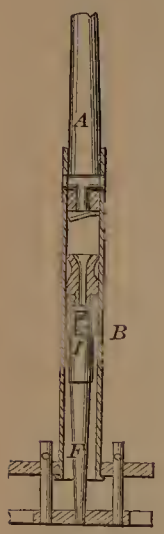


Atmospheric Churn.

2. The centrifugal churn-dasher.

This is usually a vertical tube with radiating arms

Fig. 404.



Atmospheric Churn-Dasher.

at the bottom. As the tubular dasher is rotated, the air is expelled at the ends of the radial arms, a supply entering at the open upper end of the tube.

There are many modifications of this principle, but they all possess this substantive feature.

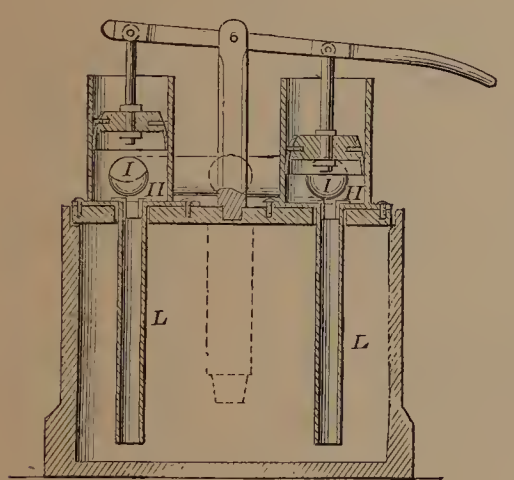
3. The reciprocating dasher.

In this case the tubular dasher has a valve which opens, on the upward motion, to admit air, and closes when the down stroke ejects the air from the tube into the milk.

In Fig. 404 the dasher is duplicated, the upper part being connected to the tubular shaft *B* and the lower part to the inner plunger *I F*. As the tube *B* rises, the plunger *I* descends, the valve *g* closes, and air enters at the upper valve-way in *A*. As the tube *B* descends, the upper valve closes, the plunger expels the air through the valve-way *a*, out at the bottom of the tube and into the cream.

In another form (Fig. 405) air at any desired temperature is forced into the churn at a point near the

Fig. 405.



Atmospheric Churn.

bottom by the reciprocating air-pumps, and has exit through the lid. As a piston rises, air enters beneath it by the valves *I* in the supply-pipe *H*. As the piston descends, the valve closes, and the air is delivered into the cream by the pipe *L*. The action of the pistons is alternate.

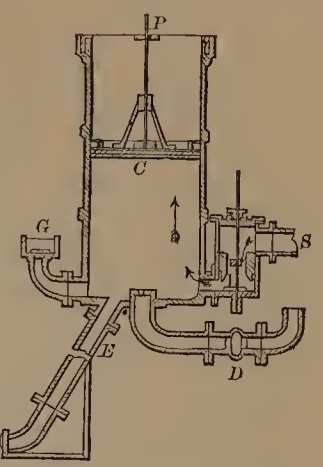
At-mos-pher'ic En'gine. Invented by Dr. Papin, of Blois, France, in 1695 ; improved by Newcomen, 1705, and Watt, 1769. It was the first good steam-engine on a working scale, and is the foundation of the Cornish engine. The present form of the engine has Watt's improvements.

In it the steam from the boiler is conducted beneath the piston, rather allowing it to rise than actually lifting it, as the weight of the pump-rod causes the pump-plunger to descend. The effective stroke is obtained by the condensation of the steam beneath the piston, when the pressure of the atmosphere on the latter lifts the pump-rod and the water.

In another application of the engine, the atmosphere raises the pump-rod, and the weight of the latter *forces* up the water.

The illustration shows the old atmospheric engine, in which water was injected into the cylinder itself for the purpose of condensing the steam below the piston, in order that the pressure of the atmosphere might be availed to force down the piston and make an effective stroke. The piston-rod *P* is connected to one end of the working-beam. The piston is shown as rising in the cylinder *C*, steam being admitted to it by pipe *S* and valve *V*. When the piston has attained its maximum hight, the valve *V* is closed, shutting off the steam, and the valve *D* is opened, admitting water at the injection-aperture. The water speedily condenses the steam, and the piston is depressed by the weight of the atmosphere.

Fig. 406.



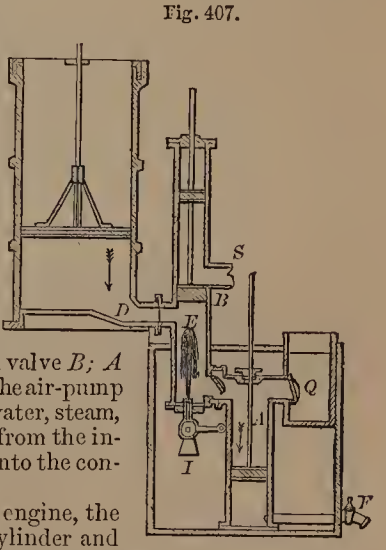
Newcomen's Atmospheric Engine.

The water escapes by the pipe *E* to the cistern called the *hot-well*, whence it is drawn for the supply of the boiler. The valve *F* opens outwardly to allow the water to escape. The air escapes by another pipe at the valve-way *G*.

The valves of this engine were originally in the form of faucets, which were turned by hand at the proper times, as we see in Worcester's, Papin's, and Savery's engines. The same plan was adopted in Newcomen's until an ingenious boy, Humphrey Potter, being placed in charge, devised in 1716 a means for connecting the lever-handles of the spigots to the working-beam, so that the motion of the latter was the means of opening and closing the respective valves at the proper times.

To the engine of Newcomen, Watt added, among other improvements, the separate condenser and the air-pump. By the former he avoided the cooling of the cylinder at each down stroke of the piston ; by the latter he made the vacuum beneath the piston more perfect.

Fig. 407.



Watt's Atmospheric Engine.

In the improved form the steam is admitted by pipe *S* and valve *B*; *A* is the cylinder of the air-pump which ejects the water, steam, and air resulting from the injection of water into the condenser at *E*.

In starting the engine, the pistons of the cylinder and air-pump being both up, any accumulation of water at the bottom of the latter is drawn off by the faucet *F*, which is then closed. The valve *B* is then raised above the steam-pipe *S*, so as to fill the cylinder, condenser, and passage *D* with steam, which ejects

the air at the valve *Q*. The slide *B* is then lowered, so as to shut off the supply of steam; the injection-faucet *I* is opened, discharging water into the condenser *E*, causing both pistons to descend. This is the effective stroke of the engine, and as the piston of the air-pump descends, the results of condensation, together with some steam and air, flow through the valve-way between the condenser and air-pump chamber, to be ejected, as the piston *A* rises, on the return stroke. The rising of the piston *A* closes the intermediate valve and opens the eduction-valve *Q*.

The latent heat of steam being about 950°, steam at 212° may be said to have 950° latent and 212° sensible heat, = 1162°. Steam mixed with 5½ times its weight of water at 32° will raise the latter to *nearly* boiling heat, though the water requires a great increment of heat to raise it a few degrees more, as so much heat becomes latent in passing to the condition of steam.

The formula for construction of these engines is given as follows by Cresy.

The cylinder has a diameter equal to half its length.

The velocity in feet per minute should be 98 times the square root of the length of the stroke.

The stroke of the air-pump should be half that of the cylinder, and the diameter of the air-piston three eighths that of the steam-piston.

The area of the steam passage is: as 4800 is to the velocity in feet per minute, so is the area of the cylinder to the area of the steam passage.

To ascertain the quantity of steam, multiply the area of the cylinder in feet by half the velocity in feet; add one fifth for cooling. This result divided by 1480 gives the quantity of water required to supply the boiler.

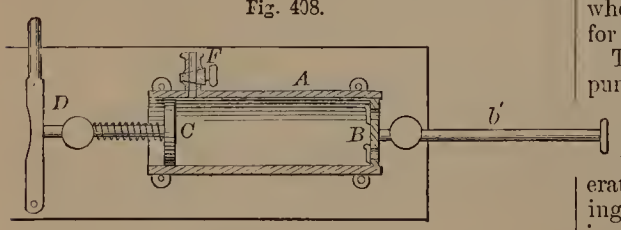
Twenty-four times this quantity of water is required for condensation.

The injection-aperture should be one thirty-sixth the diameter of the cylinder; the conducting-pipe one ninth.

To ascertain the power, multiply 6.25 times the square of the diameter of the cylinder in inches by half the velocity of the piston in feet per minute; the product expresses the effective power, or the number of pounds elevated one foot high per minute; the horse-power is found by dividing the result by 33,000.

At-mos-pher'ic Gov'ern-or. An apparatus for governing the motion of machinery by means of an imprisoned body of air subjected to pressure. The illustration shows one form of apparatus in which the brake-lever *D* may be brought into contact with some moving wheel of the machine to be regulated. The pressure of the air in the cylinder *A* upon the

Fig. 408.



Atmospheric Governor.

piston *C* is the measure of the power brought upon the brake *D*. This pressure may be decreased by allowing air to escape through the stop-cock *F*, or increased by the action of the valved piston *B*, *b'*.

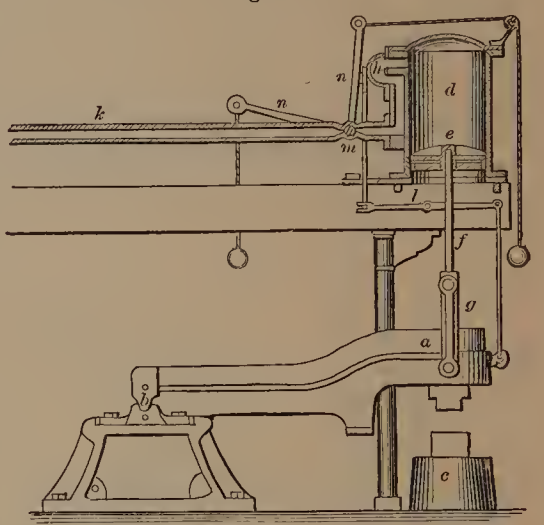
At-mos-pher'ic Ham'mer. A power-hammer driven by the force of compressed air.

In some cases the air is employed merely to lift the hammer; in other cases air is also employed as an adjunct in the effective stroke. In the latter case the operation is much like that of the steam-hammer, the main difference being in the substitution of air for steam.

In Hague's English patent some forty years since, an atmospheric hammer is shown, in which the helve is raised by the pressure of the atmosphere beneath a piston above the hammer-helve, the air being exhausted from above the piston by means of a pump; the hammer falling by its own weight when the air is admitted above the piston.

In Fig. 409, *a b* is the hammer turning upon the fulcrum at *b*; *c* the anvil; *d* a cylinder situated immediately over the hammer; *e* the piston connected with the hammer by the bar *f* and the slings *g*; *h* a slide-valve worked by the lever *l*, which is

Fig. 409.



Hague's Atmospheric Hammer.

struck by a pin on the bar *f* when the piston arrives at the top of the cylinder, depressing the valve so as to shut off communication with the air-pump and admit atmospheric air above the piston, permitting the hammer and piston to fall by their own weight.

Towards the close of the descent, the hammer, by means of a line attached to it and to the lever *l*, reverses the position of the latter and of the slide-valve, thus re-opening the communication between the cylinder and the air-pump. *k* is the pipe leading from the air-pump to the cylinder; *m* is a cock for shutting off the communication with the air-pump when the hammer is not at work; *n n* are spanners for opening and shutting the cock.

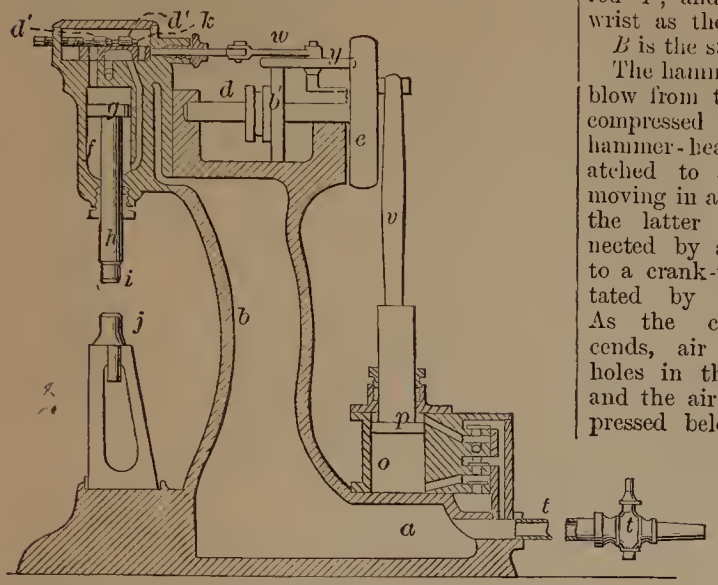
The atmospheric hammer (Fig. 410) has an air-pump and hammer combined in the same frame.

c is the band-wheel which derives its motion from the motor, — steam or water, as the case may be. *v* is the pitman, and *p* the piston operated by a wrist on the band-wheel *e* and condensing the air in the cylinder *o*. The compressed air is stored in a reservoir *a b*, and conducted to the valve-chamber.

In this chamber are a slide-valve *k* and stationary valve *d' d'*, the former operated by the valve-rod *w* from the friction-wheels *y d*.

The head of the hammer *h* is attached to a piston *g*, which works in the cylinder *f*, into which air is admitted — like steam to a double-acting steam-engine — alternately above and below the piston. The friction-wheel *b'* is spline-keyed upon the shaft

Fig. 410.

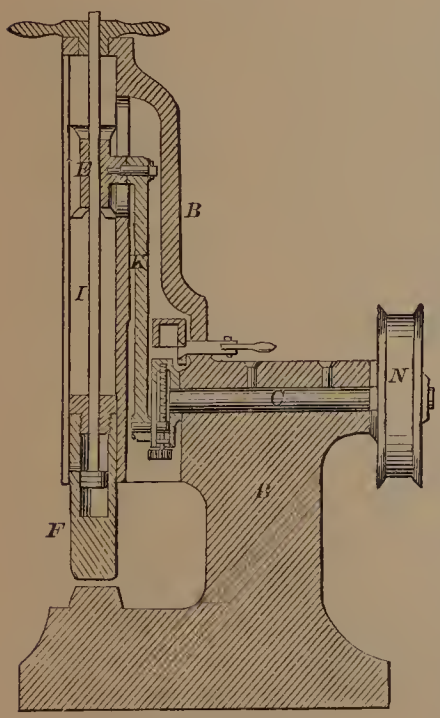


Atmo pheric Hammer.

d, and is adjustable upon the latter longitudinally, so that its perimeter shall come in contact with the under side of the wheel *y* at points more or less distant from the axis of the last-mentioned wheel. In this way the valve is made to admit more or less air to the cylinder according to the force required and the duty to be performed. If the wheel *b'* be near the center of wheel *y*, but little motion is imparted, the stroke is quick, and the blow light; but if the wheel *b'* is carried nearer to the periphery of the wheel *y*, the hammer is slower in its motion, and a more forcible blow is given.

The valve-plate *d' d'* is adjustable, but not involved in the active motions of the machine. Its adjustment affects the area of opening in the air induction-valve ports.

Fig. 411.



Atmospheric Hammer.

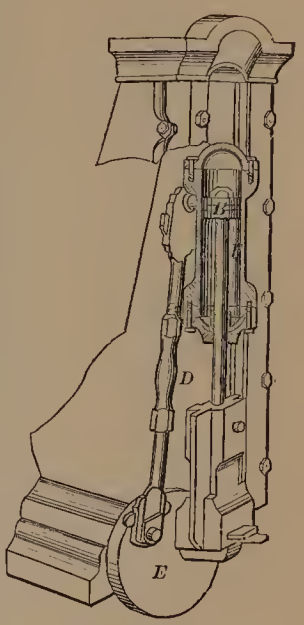
The stop-cock *t* is an escape for air when required. *i j* are hammer and anvil faces, respectively.

In another example (Fig. 411) the hammer is reciprocated by pitman connection *K* to a wrist on a crank-shaft *C*, operated by a band on wheel *N*. The hight of the hammer *F* above the anvil is graduated by the adjustment of its piston-rod *I*; and its stroke by the adjustment of the wrist as the crank-shaft.

B is the standard of the frame.

The hammer (Fig. 412) derives the decision of its blow from the force of compressed air. The hammer-head is attached to a piston *B* moving in a cylinder *F*, the latter being connected by a pitman *D* to a crank-wheel *E* rotated by the motor. As the cylinder ascends, air enters the holes in the cylinder, and the air being compressed below the piston, the hammer is lifted. As the cylinder descends, air is compressed above the piston, and is stored up to produce a sudden blow, by instant expansion after the crank and connecting-rod turn the bottom center.

Fig. 412.



Pneumatic Hammer.

At-mos-pher'ic Line. The equilibrium line of an indicator card, which shows that the steam pressure is equal to that of the atmosphere.

At-mos-pher'ic Pump. One in which the pressure of the air forces water into the pipe below the plunger. The usual form of *lift*-pump, though some lift-pumps elevate the water from immense depths in mines. The attempt in 1641 of a Florentine pump-maker to make an atmospheric pump which would elevate water 50 or 60 feet having failed, the Grand Duke asked Galileo to account for the failure. His reply was not to the purpose, but Torricelli ten years afterwards explained the cause. Galileo was by this time "in his grave." Malice had "done his worst . . . . nor steel nor poison" could "touch him further."

At-mos-pher'ic Rail'way. The idea of conveying carriages in a tube by means of atmospheric pressure seems to have originated with Dr. Papin, of Blois, in France, about the end of the seventeenth century. This extremely versatile man was the first to apply steam to raising a piston in a cylinder. He was the inventor of the Digester, and to this was first applied the lever-weighted safety-valve, also the Doctor's invention. The experiments actually entered upon by the philosopher of Blois, in the matter of compressed air, were principally directed to the transmission of power thereby. See AIR AS A MEANS OF TRANSMITTING POWER.

He placed air-compressing engines in positions where the compression could be effected by a fall of water, and pipes were to convey the air to the mine, where it was to be allowed to expand against a piston and work a pump. For some reason the project failed in its execution, but has been more successful in other hands.

The suggestion of conveying goods, parcels, and passengers by compressed air appears to have been rather a chance suggestion than to have been seriously entertained, and it has been again and again revived in the 130 years that intervened between Papin

and Medhurst, who again urged the project about 1810.

Medhurst, in 1810, published an account of "a new method of conveying goods and letters by air," and in 1812 extended the idea so as to provide for the transmission of passengers, whom he proposed to transport at the rate of fifty miles per hour. His project consisted of an air-tight tube, containing a pair of cast-iron wheel-tracks on which the carriage has to run. The carriage had the form of the tube and a certain amount of packing to prevent the leakage of the air, which was condensed behind it and formed the propelling power.

His calculation was as follows: —

To obtain a speed of 50 miles per hour, in a tube six feet in diameter, would require a constant impelling force of 861 pounds moving at the rate of 73 feet per second, equal to the power of 180 horses. Taking the consumption of fuel of a steam-engine of that size at 12 bushels of coal per hour, three tons of goods might thus be conveyed 50 miles at a cost of 12*s.* and at the speed mentioned. The project fell upon the dead ear of the public.

Twelve years afterward the idea was revived in a changed form. Retaining the tube and carriage of Medhurst, Vallance, in 1824, obtained a patent in England for his modified plan, which consisted in using a partial vacuum in front of the carriage, allowing the natural atmospheric pressure in the rear to impel the carriage. In this he differed from Papin and Medhurst, who proposed a plenum in the rear, and not a vacuum in the advance.

Vallance's tunnel was to be of iron or vitrified clay, and he constructed a short tube in his garden at Brighton, which worked on the moderate scale on which it was applied, and was occasionally noticed in the journals of the day.

So far all the inventors have proposed that the carriage shall travel in the tube in the manner of a piston. The next proposition introduces a new feature.

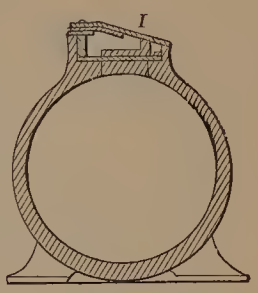
In 1834, Pinkus, an American citizen residing in England, took out a patent for an apparatus which he termed a Pneumatic Railway, and laid the foundation of most of the successful applications of the atmospheric principle which have since been introduced.

Pinkus's patent embraces a main with a continuous longitudinal slot on its upper surface, and an elastic gravitating valve to fill the slot. The tube was to be about forty inches in diameter, laid down between a pair of rails on which the carriages were to run, and having within it a piston attached by a vertical arm to the leading carriage of the train. The vertical arm passed through the slot in the upper part of the tube, and displaced the valve as the piston advanced, the valve closing in the rear of the arm after allowing some air to enter. The valve consisted of a thick cord saturated with a composition of wax and tallow.

Clegg patented some improvements in 1839.

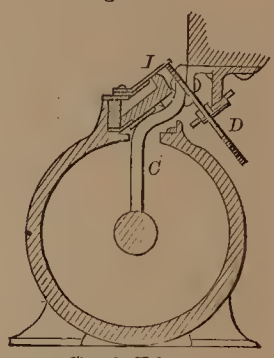
The valve works on a hinge of leather or other flexible material, which is practically air-tight, similar to the valves commonly used in air-pumps; the extremity or edge of the valve is caused to fall into a trough containing a composition of beeswax and tallow, or other substance which is solid at the temperature of the atmosphere, and becomes fluid when heated a few degrees above it.

Fig. 413.



Clegg's Valve closed.

Fig. 414.



Clegg's Valve open.

An outer flap of sheet-iron *I* covers the leather valve when the slot in the tube is closed behind the colter *C*, and is raised before the colter by the oblique roller *D*, Figs. 414, 415.

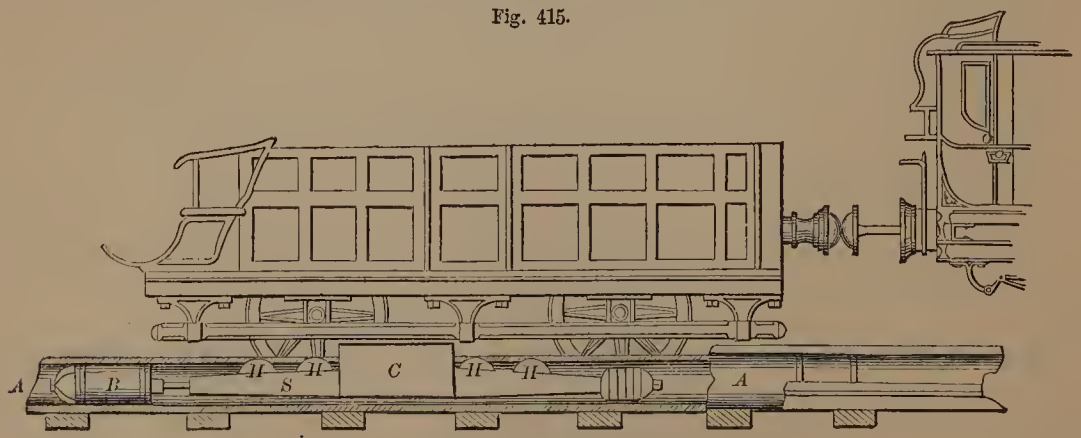
The tube *A* was coated inside with hard tallow, to make it perfectly smooth, and the piston *B* was furnished with a rod *S*, about 14 feet long, to which were attached rollers *H H*, which pressed open an air-tight valve along the top of the tube as the piston advanced. The piston was attached to the first, or driving, car by means of a colter *C*, and to the driving car was attached a copper vessel, several feet in length, heated with coke, for the purpose of melting the composition after the valve had been pressed down by the closing roller.

The valve behind the lifting-bar was held up for a sufficient time by the rollers *H H*, to allow the air to pass in behind the piston.

The pipe was divided by valves into three-mile sections, a steam-engine working the air-pump of each. The main was cast in sections nine feet long, joined by an oil cement.

An experimental line was laid down at Worm-

Fig. 415.



Clegg's Atmospheric Railway.

wood Scrubs by Clegg and Samuda. The line was half a mile long, with a rise of 1 in 120 for a part of the distance and 1 in 115 for the remainder. The diameter of the main was nine inches. The exhaustion was produced by means of an air-pump 37 inches in diameter and 22 inches stroke, worked by a condensing engine of 16-horse power.

This arrangement was employed from 1844 to 1855, on the line from Kingston to Dalkey, Ireland, 1¾ miles long. It is stated that an exhaustion of 15 inches could be produced in two minutes, and a rate of 50 to 60 miles an hour could be obtained. The rise is 71½ feet in 3,050 yards.

The diameter of the main was 15 inches. The double-acting air-pump was 66½ inches diameter, with a stroke of 66 inches. It was worked by a high-pressure condensing-engine of 34 inches diameter and 66 inches stroke, working expansively.

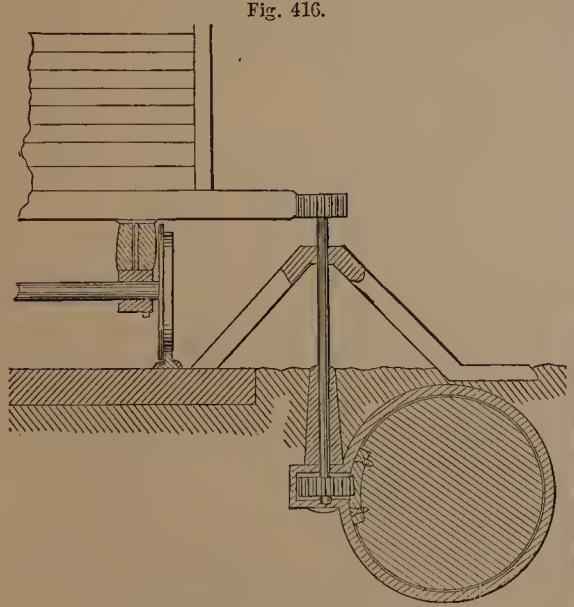
The stoppage was effected by a powerful brake, and, if necessary, by an arrangement operatable from the car, by which the valve was opened in advance, so as to destroy the vacuum.

Railroad engineers expressed very various opinions on the feasibility of the new project, Brunel and Stephenson took opposite sides, as usual, and the plan was tried in South Devonshire, on the Croydon Railway, and elsewhere. It eventually failed by reason of complexity and liability to get out of order, leakage of air impairing the vacuum.

The advantages are: facility in ascending heavy grades, rendering less cost necessary in leveling and grading; and security against collision.

Another form of conveying the motion of the piston in the atmospheric tube was invented by Pilbrow, and was intended to avoid the continuous opening in the tube, and the necessity for the valve which closed it on the Pinkus principle. Pilbrow made a toothed rack on the edge of his piston, which rack engaged with a series of pinions in air-tight boxes attached to the sides of the tube at short intervals. The vertical axes of these pinions passed upward through stuffing-boxes, and at the top were provided with other pinions which geared into racks on the sides of the carriages. Thus, the motion of the piston rotates the pinions successively as it advances along the line, and they communicate motion to the carriage. It is not known to the writer whether this device ever came into practical use.

Fig. 416.



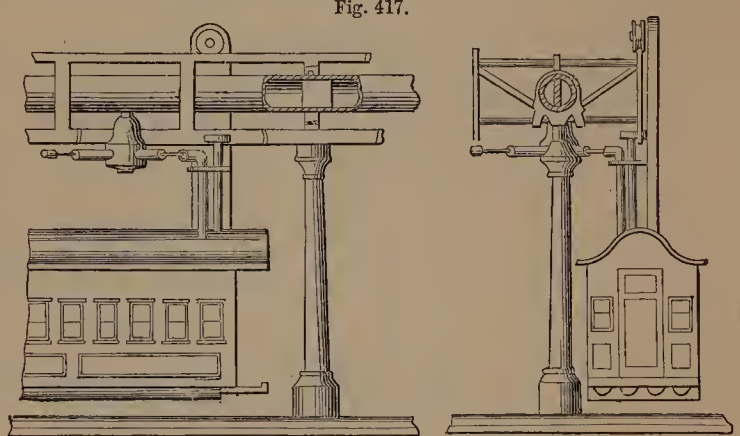
Pilbrow's Atmospheric Railway.

Keene and Nickel's Atmospheric Railway (English) was designed to act by compressed air in a tube laid along, under ground, between the lines of rail. Stationary above the surface are certain standards with grooved sides, in which are elastic pipes fed from the reservoir-pipe below. Beneath the carriage to be driven are rollers which are made to condense the elastic pipes into the hollowed sides, and the air, being admitted in the rear, expands against the peripheries of the drums beneath the carriage, and forces them to rotate and the carriage to advance.

Henry's Atmospheric Railway, English Patent, August 7, 1845, specifies a side slit in the atmospheric tube, and the longitudinal valve closed by the pressure of a long bag or hose, inflated with air and protected by a shield of wrought-iron bolted to the tube.

The vacuum in the tube is produced by first filling with water a number of large, close reservoirs connected with the tube by pipes and valves, opening the communication between the two, and then allowing the water to run off.

Fig. 417.



Elevated Railway.

The same mode of producing the vacuum was described in Aitken's English Patent, February 24, 1844.

In another application of the air, a tube laid throughout the line is filled with compressed air, and is used as a reservoir wherefrom compressed-air locomotives may renew their supply of air.

This is suggested in connection with one form of Elevated Railway.

In one form (Atmospheric Elevated Railway), the tube, which extends the whole length of the railway, is filled with compressed air, for the supply of the tanks on the cars, which form reservoirs for the supply of the air whereby the air-engines are driven. The tube at suitable intervals has valves and discharge-pipes for the supply of the engines on the cars.

The original proposition to use a transportation-tube and compression or exhaustion of air for the conveyance of lighter articles of freight and letters, has been put in practice successfully. A company was formed, and a permanent line laid down in 1859, for conveying parcels and light goods from the

Euston Square Station and the Post-Office in Eversholt Street, London, and an extension was opened in 1865.

This realizes the dreams of Papin and the hopes of Medhurst, nearly two hundred years after the busy speculations of the first and fifty years after the disappointment of the second.

A late act of Congress (1872) appropriates $15,000 for a pneumatic dispatch-tube between the Capitol and the Government Printing-Office, Washington.

The pneumatic dispatch-scheme has been put in operation at the Crystal Palace, Sydenham, England, to convey regular passengers.

The tube extends from the Sydenham entrance to the armory near Penge Gate, a distance of about a quarter of a mile; and it is, in fact, a simple brick tunnel, nine feet high and eight feet wide, — a size that renders it capable of containing an ordinary railway-carriage. The piston is rendered partially air-tight by the use of a fringe of bristles extending nearly to the brickwork of the tunnel and its floor. A fan 20 feet in diameter is employed to exhaust or to force in air, and perhaps it is impossible to devise any other expedient so well calculated to answer the required purpose. It must be remembered that either a plenum or a vacuum equivalent to .5 of an inch of mercury is quite sufficient to propel even a heavy train at a high speed on a moderately level line. In the present instance the motive-power is supplied by an old locomotive borrowed from one of the railway-companies, which is temporarily mounted on brickwork. The tires have been removed from the driving-wheels, and these last put the fan in motion by straps.

The line is a quarter of a mile long; a very small portion of it, if any, is level, but it has in it a gradient of one in fifteen, — an incline which no engineer would construct on an ordinary railway; and as it is not a level line, so it is not a straight one; for it has curves of only eight chains radius, which are shorter than those usually found in existing railways. The entire distance, 600 yards, is traversed in about 50 seconds, with an atmospheric pressure of but 2½ ounces. The motion is, of course, easy and pleasant, and the ventilation ample, without being in any way excessive. See PNEUMATIC TUBULAR DISPATCH.

At-mos-pher'ic Spring. A spring formed by a confined body of air either operating by means of a cylinder and piston or by an air-tight bag.

It has been suggested for gun-carriages, to take the jar of the recoil, and also for railroad-cars. See PNEUMATIC SPRING.

A-tom'ic Weights. The appended list of chemical equivalents differs much from those of older and other authorities, but is offered as the best within the reach of the present writer. It differs also from a short list of chemical equivalents on page 66.

TABLE OF ATOMIC WEIGHTS.

Compiled according to the Latest Determinations, for the Use of the Students of the School of Mines, Columbia College, Jan., 1872.

BY C. F. CHANDLER, PH. D.

Hydrogen = 1.

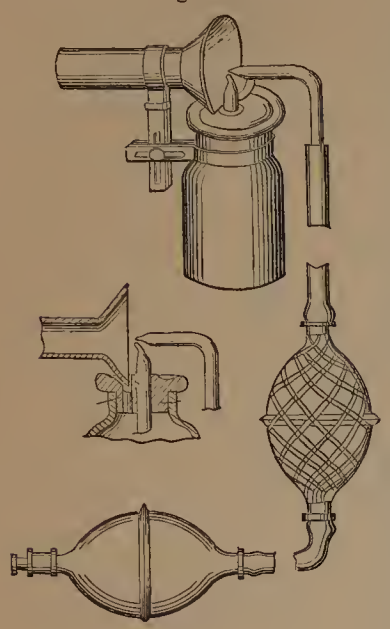
	SYMBOL.	OLD.	NEW.
Oxygen,	O.	8.	16.
Aluminium,	Al.	13.7	27.4
Antimony,	*Sb.*	122.	122.
Arsenic,	*As.*	75.	75.
Barium,	Ba.	68.5	137.
Bismuth,	*Bi.*	210.	210.
Boron,	*B.*	11.	11.
Bromine,	*Br.*	80.	80.
Cadmium,	Cd.	56.	112.
Cæsium,	*Cs.*	133.	133.
Calcium,	Ca.	20.	40.
Carbon,	C.	6.	12.
Cerium,	Ce.	45.7	91.3
Chlorine,	*Cl.*	35.5	35.5
Chromium,	Cr.	26.1	52.2
Cobalt,	Co.	30.	60.
Columbium,	*Cb.*	94.	94.
Copper,	Cu.	31.7	63.4
Didymium,	D.	47.5	95.
Erbium,	E.	56.3	112.6
Fluorine,	*F.*	19.	19.
Glucinum,	Gl.	4.6	9.2
Gold,	*Au.*	197.	197.
Hydrogen,	*H.*	1.	1.
Indium,	In.	56.7	113.4
Iodine,	*I.*	127.	127.
Iridium,	Ir.	99.	198.
Iron,	Fe.	28.	56.
Lanthanum,	La.	46.	92.
Lead,	Pb.	103.5	207.
Lithium,	*Li.*	7.	7.
Magnesium,	Mg.	12.	24.
Manganese,	Mn.	27.5	55.
Mercury,	Hg.	100.	200.
Molybdenum,	Mo.	48.	96.
Nickel,	Ni.	29.	58.
Nitrogen,	*N.*	14.	14.
Osmium,	Os.	100.	200.
Oxygen,	O.	8.	16.
Palladium,	Pd.	53.	106.
Phosphorus,	*P.*	31.	31.
Platinum,	Pt.	98.7	197.4
Potassium,	*K.*	39.1	39.1
Rhodium,	Ro.	52.	104.
Rubidium,	*Rb.*	85.4	85.4
Ruthenium,	Ru.	52.	104.
Selenium,	Se.	39.5	79.
Silicon,	Si.	14.	28.
Silver,	*Ag.*	108.	108.
Sodium,	*Na.*	23.	23.
Strontium,	Sr.	44.	88.
Sulphur,	S.	16.	32.
Tantalum,	*Ta.*	182.	182.
Tellurium,	Te.	64.	128.
Terbium,	Tb.	37.7	75.4
Thallium,	*Tl.*	204.	204.
Thorium,	Th.	59.2	118.4
Tin,	Sn.	59.	118.
Titanium,	Ti.	25.	50.
Tungsten,	W.	92.	184.
Uranium,	U.	60.	120.
Vanadium,	*V.*	51.3	51.3
Yttrium,	Y.	30.8	61.6
Zinc,	Zn.	32.5	65.
Zirconium,	Zr.	44.8	89.6

At'om-i-zer. The atomizer is designed to reduce a liquid into spray for disinfecting, cooling, or perfuming purposes.

Several different modes of operation are adopted. One style consists of a blast of air presented at right angles across an opening in the end of a tube which communicates with a supply of the liquid. This acts somewhat on the principle of the Giffard Injector, raises the liquid, and by contact disperses it, reducing it to a fine spray. The contiguous air and fluid tubes are connected to the vertical or cup tube, so as to be reversible in relation thereto.

The atomizer-tube is used to diffuse a cooled liquid in spray to render it more effective in absorbing the sensible heat of a room or vessel. There are

Fig. 418.



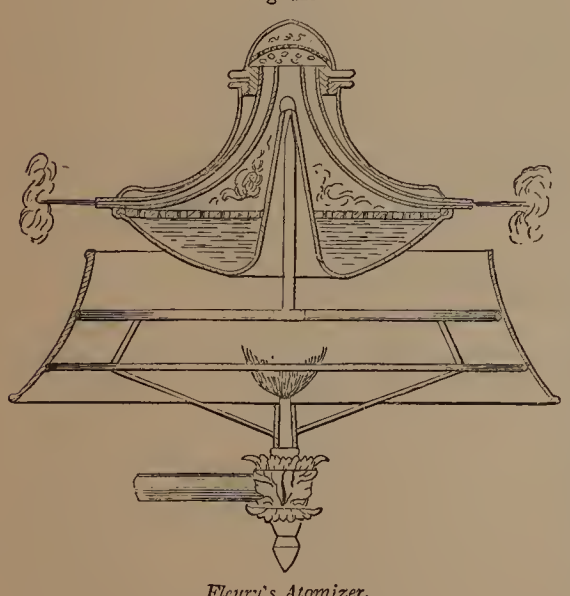
Atomizer.

many adaptations to boats, granaries, hospitals, fruit-chambers, and for making ice.

In the atomizer (Fig. 418) the atomizing blast is ejected by an elastic bulb, and crosses the orifice of the tube leading from the vessel of liquid, whose contents are thereby raised, and driven, in the form of spray, through the shield, which directs it upon the part where local anæsthesia is required. The shield has a flaring and cylindrical portion, is hinged to the liquid vessel, and adjustable in relation thereto, and drains into the vessel.

In another apparatus for impregnating the air with antiseptic vapors, to prevent infection and purify the atmosphere of hospitals, etc., a trough holds the antiseptic liquid, such as tar, carbolic acid, turpentine, etc., from which the vapors are to be generated. A frame contains a number of vertical perforated plates, which, after dipping in the liquid, are supported in a raised position, so as to part with their vapors to the atmosphere.

Fig. 419.

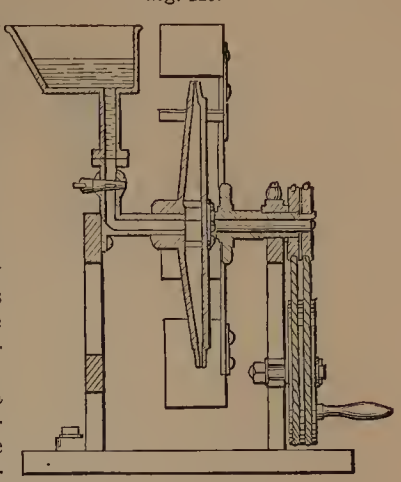


Fleury's Atomizer.

In Fig. 419 the vessel is supported on vertical pivots above a gas-burner, and contains a disinfecting liquid or perfume. When heat is applied, the vapor escapes by the hollow arms above, revolving the vessel, on the principle of Hero's æolipile, and disseminating steam and spray in the apartment. The apparatus is supported upon a pivot erected upon the frame of the shade, which is secured to the gas-burner in the usual manner. The atomizer is also used in connection with an air-carbureting apparatus.

In the early and simple forms of inhalers the liquid was vaporized by heat, and this is a desirable condition for some modes of treatment. In many cases, however, the increased temperature produces injurious effects. A means of changing the liquid into mist, which does not act on the Giffard principle, as in the modern form of atomizer, is shown in Fig. 420. The rotary wheel has hollow, radial arms, terminating in very small orifices, through which the liquid is thrown in jets by centrifugal action. The liquid is ejected against oblique plates attached to the ends of the radial arms of another wheel which rotates in a direction the reverse of the former. The contact of the liquid with the plates reduces it to a spray, which pervades the chamber in which the operation is carried on, and the patient is caused to breathe the mist either by a tube or otherwise.

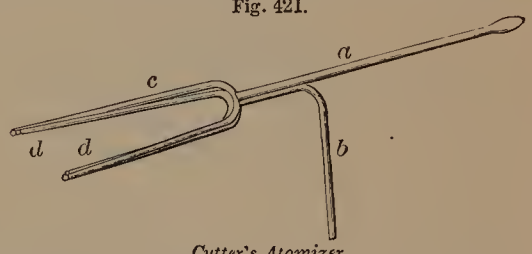
Fig. 420.



Atomizing Wheel.

In the anæsthetic instrument for dental purposes, each tube is bifurcated, so as to reach the inner and outer sides of the jaw simultaneously, by the branches *d d*. The straight tube *a* carries the air-blast,

Fig. 421.



Cutter's Atomizer.

and thus draws a current of liquid whose rapid evaporation produces cold and local anæsthesia. The lower end of the bent tube *b* is dipped in the liquid, and it discharges at its end, while the air-tube *a c* discharges just in advance of it, producing a spray of the liquid.

The atomizer is adapted for operation by hand or foot bellows (see Fig. 181). It consists of a hollow curved tube, made of German-silver, one extremity of which has an adjustable conical cap, while the other passes down into the bottle through a perforation in the cork. A short distance above the cork this tube has another tube joined to it at right angles, and which is attached to the india-rubber tubing. Within the second tube there is contained a capillary one, which extends from within a line or two of the extremity of the cap nearly to the bottom of the bottle, and beyond the bottled extremity of the larger tube. Near its upper extremity this capillary tube perforates a cylinder of metal, which almost completely occupies the caliber of the larger tube, and would entirely plug it up except that it has longitudinal grooves upon its surface. Pressure

upon the hand-ball forces air through the other ball, and so to the cavity of the curved tube. One column of this air passes upward through the tube, and the other downward into the bottle. The upward column passes through the grooves in the circumference of the plug into the cavity of the cap, and escapes through the capillary orifice at its tip. This column of air, passing over the extremity of the capillary tube, creates a vacuum in it, which is supplied by the liquid contents of the bottle, upon which one of the columns of air is pressing. The other column of air divides into spray the drops as they issue from the inner tube.

The theaters of the Romans were fitted up with numerous concealed pipes, that passed in every direction along the walls, and were connected to cisterns of water or to machines for raising the latter. Certain parts of the pipes were very minutely perforated, and were so arranged that, by turning one or more cocks, the liquid escaped from them, and descended upon the audience in the form of dew or extremely fine rain. This effectually cooled the heated air, and must have been exceedingly refreshing to the immense multitudes, especially in such a climate as Italy.

"The dining-rooms of Nero's golden house were ceiled in such a manner that the attendants could make it rain either flowers or liquid perfumes. At one feast 100,000 crowns were expended in perfumed waters." — EWBANK'S *Hydraulics*.

It is possible that the Romans extinguished flames in the same manner. See also Sir William Congreve's English patents Nos. 3201, 3606; 1809 and 1812.

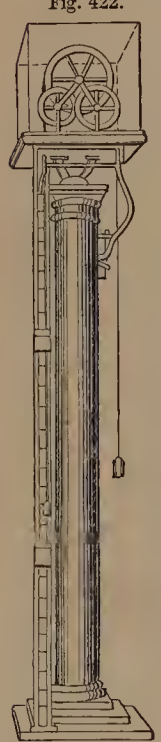
At-tached' Col'umn. (*Architecture.*) One partially imbedded in a wall. An *inserted* column.

At-tach'ment Screw. A binding screw.

At'tic. An upper story, when the ceiling is horizontal. Otherwise it is a *garret*.

At'tle. (*Mining.*) Rubbish containing little or no ore. Synomyms: *addle; adall; attal.*

Fig. 422.



Atwood's Machine.

At'wood's Ma-chine'. A scientific apparatus to illustrate the theory of accelerated motion.

It consists of a wooden column, about 10 feet high, resting on a base and supporting a series of anti-friction wheels, which support a large central roller, over which passes a cord having equal weights at each end, so as to be *in equilibrio*. By means of a graduated staff at one side the rise of one and fall of the other weight are indicated in feet and inches.

A small additional weight, being added to one of the large weights, causes it to descend with a velocity due to its excess of gravity over the other; and this being very small, the motion is correspondingly slow, rendering the resistance of the air inappreciable, and enabling the rate of descent to be ascertained with great accuracy.

The counterpoise weights of this apparatus enable the constant acceleration of speed caused by gravity in a falling body to be shown and measured within the space of a few feet more accurately and satisfactorily than could be done by the fall of a weight not thus counterpoised from a considerable hight.

It may also be employed to illustrate the laws of retarded motion, impact of bodies, and resistance of fluids, as well as other phenomena of a similar nature.

Alhazen the Saracen, A. D. 1100, in his "Book of the Balance of Wisdom," considered the subject of gravity, and asserted that it diminished with the distance. It was reserved for Newton to determine that it decreased as the square of the distance. Alhazen determined correctly the relation between the velocities, spaces, and times of falling bodies. The University of Cordova was the intellectual center of Europe in his day. The Khalif Alkamen's library was so large that its catalogue filled 40 volumes. The people of Cordova could walk paved streets at night 10 miles in a straight line, by the light of public lamps, when London and Paris were dark and dismal mud-holes.

Galileo, born 1564, considered the subject of acceleration of force, and determined the relation between the spaces of descent and the times. He used inclined planes, by the aid of which he conveniently diminished the velocity without changing the nature of the result.

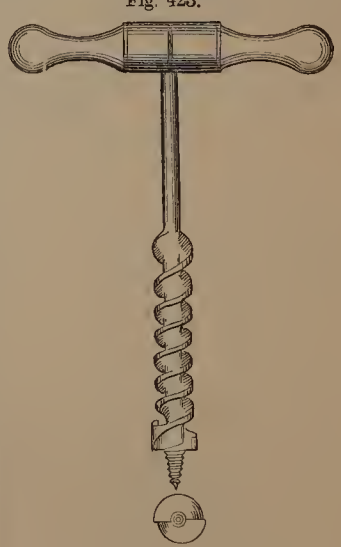
Au'ger. The first boring-tool may be assumed to have been an awl of some kind. Pliny states that Dædalus invented the gimlet, — 1240 B. C. It was destitute of a screw-point, but it may have had a hollow pod, and a cross-head forming a handle. Awls are shown in Egyptian tombs of 1706 and 1490 B. C. The screw-point was added to the gimlet in course of time, and, within our own recollection, the twisted shank, which makes it self-discharging. This hint was taken from the auger proper, which may be called a magnified gimlet, now that their specific features have become so closely assimilated in form and function. The auger (*terebra*) was a Greek tool.

The *Teredo navalis* is much older still, and carries an auger in his head; — a great bore he is.

From the early descriptions, the auger appears to have been considered a shipwright's tool. It formerly had a curved, sharpened end, and a concavity to hold the chips; this was a *pod* auger. To this a lip was subsequently added for some kinds of boring, and in course of time the depression grew into a spiral, which allows the chips to escape while the boring proceeds, instead of withdrawing the tool as the pod becomes filled.

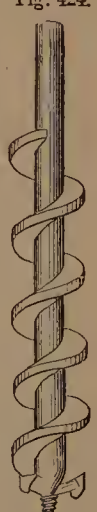
The *Twisted Auger* is an American invention, and was made by Lilley, of Mansfield, Connecticut, about the beginning of the present century, and afterwards by Gurley, of the same place.

Fig. 423.



L'Hommedieu's Auger.

Fig. 424.



Shetter's American Auger.

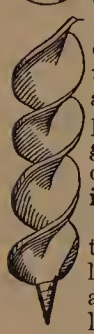
Fig. 425.

Cook's Auger.

Augers may be classified as augers; hollow augers; annular augers; taper augers; augers with secondary borers, reamers, or countersinks, or having expansive cutters. Auger-gages, auger-handles, and machines for making augers, will be considered separately.

L'Hommedieu's *Auger*, 1809 (Fig. 423), has two pods, two cutting-lips, a central screw, and a twisted shank. It is hardly fair to say that it is perfect of its kind, as so many improvements have followed; but it is, on a smaller scale, like Stephenson's "Rocket" Engine, the type of its class. The form of auger which in England is called the "American" pattern was patented by Shetter, March 21, 1831. It has a spiral blade around a cylindrical core, and was long a favorite. The "good workmen" who "never quarrel with their tools" do not seem to have retained this form in the estimation it once held. It probably offers more impediment to the discharge of the chips than does the shank made from a flat blade twisted into a spiral. Some auger-shanks have an *increase twist* as they recede from the point; this gives a greater freedom of discharge by increasing the caliber of the canal as the chips ascend.

Fig. 426.



Kasson's Auger.

In the auger (Fig. 425) the cutting-lips commence at the screw or point, and extend therefrom nearly at right angles, until about half-way from the center to the outer point, and then curve upward and forward, giving a nearly semicircular form to the outer portion of the lips, which are curved in the horizontal and vertical planes.

The auger (Fig. 426) permits the formation of cutting-lips at any point on the length of the spiral, by cutting off the twist at any point, in a plane vertical, or nearly so, to the axis of the auger, and then sharpening its edges. The front surfaces of the twist are concave, and the rear convex.

The *Slotting Auger* cuts laterally, the work being fed against its side. It is used in wood-mortising and slotting machines. The twist is formed into a number of chisel-shaped lips rising from the edge of the twist and presenting sharp edges in the direction of the bore of the auger, so that the wood may be cut laterally if pushed against the instrument after the hole has been bored to a sufficient depth for the proposed mortise or slot. The end-lips may be made chisel-shaped or hollow like a gouge, as desired. If the auger or bit be held in the rapidly revolving arbor of a mortising or boring machine, the mortise may be cut at full depth, at one operation, by moving the wood laterally against the auger. The corners of the mortise are afterwards cut out by a chisel.

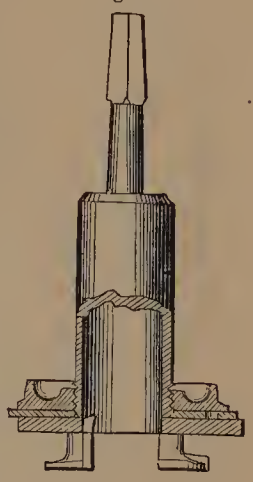
Fig. 427.

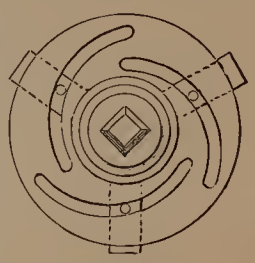
Slotting Auger.

Hollow Augers are used for forming tenons on the ends of spokes, bedstead-rails, chair rounds and legs, table-legs, and many other articles. Those on a more extended scale, which allow the material to pass clear through them, are properly turning-machines, and are adapted for making scythe-snaths, broom-handles, etc.

The hollow auger, as a tool, operates to a certain length on the object, after which the auger or the object is withdrawn. Means for measuring the stroke are frequently found in the construction of the tool, as by the depth of the socket; but other means may be used, and are known as *auger-gages*.

Fig. 428.



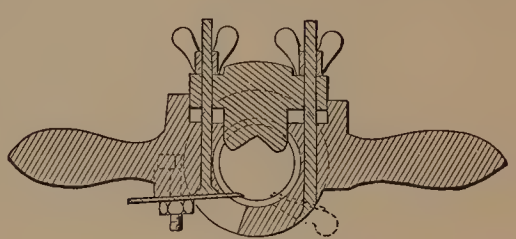


Hollow Auger.

This tool (Fig. 428) is adjustable for boring holes of different sizes. The rotary disk has eccentric slots acting upon pins inserted into the backs of sliding cutter-heads, so that they are driven out or drawn in simultaneously, and fastened by a jam-nut, which holds them in the required adjustment. The above is adapted to be used as a bit in a brace.

Fig. 429 has cross-handles like an auger. The cutting-tool is so attached as to project within the opening, and the size of the tenon is regulated by the adjustment of the angular rest. The tool has the usual auger-handles, in which respect it differs from most of its class. They are

Fig. 429.



Hollow Auger.

usually attached to braces or to mandrels rotated in bearings similar to those of the lathe-head.

A dozen others might be cited, but these are probably sufficiently descriptive.

Fig. 430.

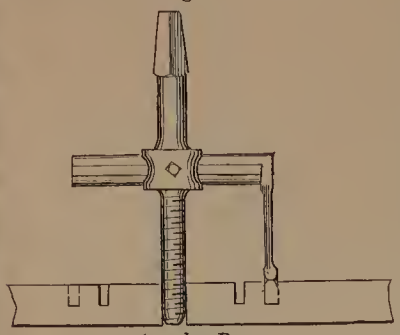
Annular Auger.

Annular Augers cut an annular groove, leaving "land" on the inside *and outside* of the channel. The example (Fig. 430) is adapted for boring cylindrical blocks out of a board, the lower edge of the tube being serrated. Fitted inside the tube is a cylindrical plug with a central point. On the reduced shank of the plug is a spiral spring, which keeps the point extended, except when pressure is applied to the tool in boring.

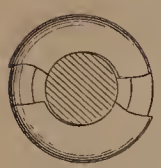
The cutters on the end of the tube (Fig. 431) make an annular groove and leave a core of wood in the center, the chips being withdrawn continuously by the spiral blade on the tube. The cutting-lips start at the periphery of the bit, and extend towards the center in concave lines, till they terminate at the inner portion of the tube, where their direction approaches a line parallel with the axis of the auger. In a subsequent form a number of tubes are arranged concentrically, so as to cut concentric, annular grooves sim-

Fig. 431

Fig. 432.



Annular Borer.

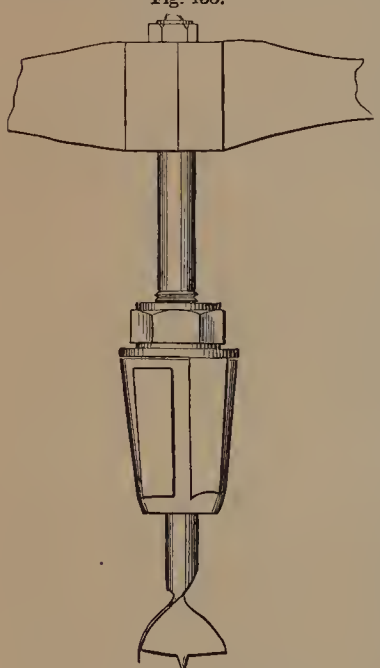


Annular Auger.

ultaneously, and produce a nest of cylinders out of the same stick or board.

Yet another form is found in the tool (Fig. 432) sometimes known as a button-tool. It has an upright center standard, with a fine feeding-screw on the lower end. The cutter is attached to a radial arm, and is adjustable, so as to describe the diameter required for the hole. The cutter is fed to its work by the thread on the standard, and the chips are ejected by the curved neck.

Fig. 433.



Kirby's Taper Auger.

Taper Augers are used for reaming out bungholes, making butter-prints, etc. The center bit bores a hole, and is succeeded by the taper reamer, which has a throat for the chips, cut through from the edge of the bit on one side to the opposite side of the stock.

The *Bunghole Reamer* (Fig. 434) has a tapering pod, and a cutting-lip on one side; the lower end is closed to receive the chips, and is open at the top, except a bail to which the handle is fastened. On one side is an adjustable gage and index to determine the size of the bore.

The ordinary form of bunghole borer is shown in Fig. 435. This has a volute-shaped blade with a sharpened, salient spiral edge and a gimlet point. It, like most of its class, is for reaming out bungholes and taps.

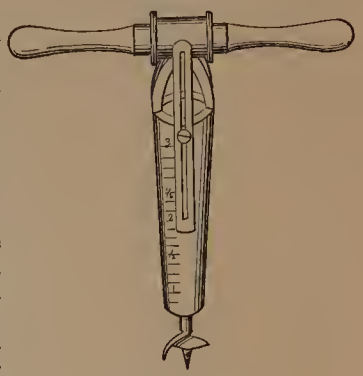
Augers are sometimes provided with secondary borers, reamers, countersinkers, or expansive cutters.

In Fig. 436 the reamer or secondary borer is formed in two pieces, and is clamped to the auger-shank at the required distance from the end of the tool, and at the same time is adjustable to ream out a hole of the required diameter. The clamp is shown separately in the upper portion of the figure.

In Fig. 437 the countersink is attached to the auger-shank at the required spot, but does not entirely surround the shank, the opening corresponding with the twist of the shank, so that the discharge of chips is not interrupted.

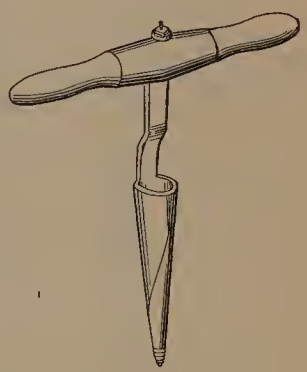
In Fig. 438 the plate is received into a longitudinal slot in the auger-shaft, and one end is secured by a temper-screw. A pin, passed through one in the series of holes in the shaft, engages a hole in the oblique series in the plate, and determines the radial adjustment and consequently the diameter of hole bored by it.

Fig. 434.



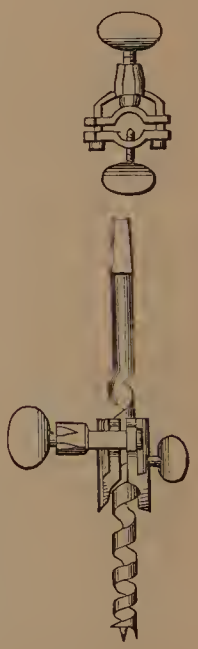
Bunghole Reamer.

Fig. 435.



Crocker's Taper Auger.

Fig. 436.



Counter-Borer.

The shanks and turned cutting-edges of the expanding bits in Fig. 439 pass through a mortise in the head of the tool, and are secured to their adjustment by a key. Their radial adjustment adapts them to bore holes of varying sizes.

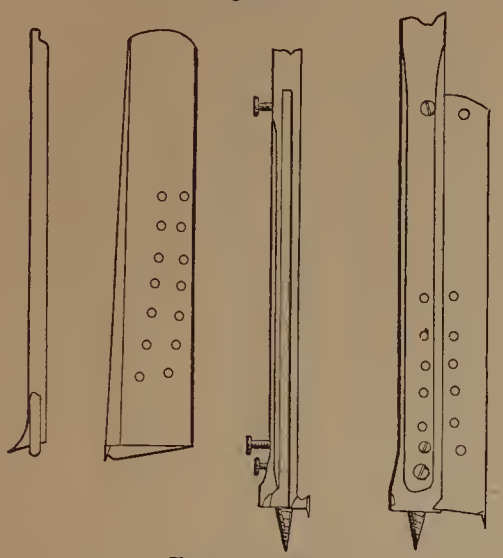
In Fig. 440 the cutter is adjustable eccentrically, and is held by a dovetailed groove and tenon. The cylindrical core is solid, and the center point is removable. The spiral has a sharp edge. The adjustment of the cutter on its eccentric pivot varies its radial sweep in boring, and it is thereby adapted to bore a hole of the required size, within the limit of its capacity.

Fig. 437.

Countersink.

Among the other uses of augers may be mentioned that of felling trees in the Mammoth Grove, Calaveras County, California. This grove is in a gently sloping valley, heavily timbered, situated on the divide or ridge between the San Antonio branch of the Stanislaus River, in latitude 38° north and longitude 120° 10′ west, and 5,200 feet above the level of the sea; here, within an area of about eighty acres, and high above the surrounding trees of the forest, can be seen

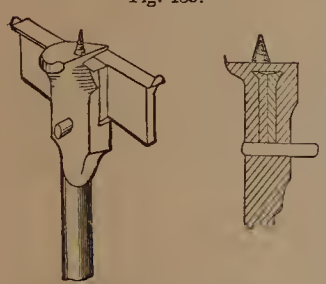
Fig. 438.



Expanding Auger.

the stately heads of these evergreen forest giants, the *Sequoia gigantea*. These trees are now growing in many parts of Great Britain and France, from California cones or burs, and no native trees are equal to them in the rapidity of their growth.

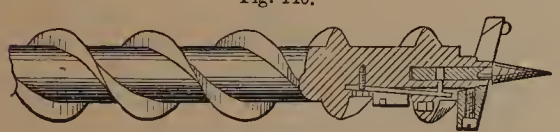
Fig. 439.



Expansible Auger.

There are twenty of these trees that will average 25 feet in diameter at the base. One of the largest now standing is called the "Mother of the Forest," and has been stripped of its bark 116 feet high, and still measures in circumference at the base 84

Fig. 440.



Expansible Auger.

feet; 20 feet from the base, 69 feet; 70 feet from the base, 43 feet 6 inches; 116 feet from the base, 39 feet 6 inches; circumference at the base, including bark, 90 feet. Its hight is 310 feet, and it is supposed to be 3,000 years old; the average thickness of the bark is 11 inches, but in some of the trees it is as much as 22½ inches.

The "Big Tree," as it was called, contained 500,000 feet of inch lumber. It was felled by five men working 22½ days, making 112½ days' labor to fell one tree. This tree measured 92 feet in circumference at the base. It was not cut down with axes, but was bored down with long pump-augers, and the wood remaining between the holes was cut off with chisels on the end of long sticks. A building, in which was a telegraph-office, was erected on the stump, which served as a floor, having been hewn off smooth. A bowling-alley was also built on the remainder of the tree, after a large part of it had been worked up into canes and sold.

The body of the "Father of the Forest" which lies half buried in the earth, measures 110 feet in circumference at the base, and 200 feet in length to the first branch, and, being hollow, a person can walk that length erect. The estimated hight of this tree when standing is 400 feet. The "Burned Tree," prostrate also, is hollow 60 feet, and persons can ride on horseback through it for that distance; it is 97 feet in circumference, and was 330 feet high. There are several other trees of immense size, and variously named.

Au'ger-bit. A boring-bit with a twisted shank, which clears the chips out of the hole.

An auger of a size adapted to be set in a brace or stock, to be revolved thereby.

Au'ger, Earth-bor'ing. A tool for boring holes in earth which is not too compact. There are quite a number of these, varying in detail, but possessing the same general characteristics. The ordinary kind (Fig. 441) has a nearly circular disk, with a lip projecting downward, to scrape up the earth which accumulates above the blade as the latter is rotated. The blade is occasionally raised to the surface to dump its load.

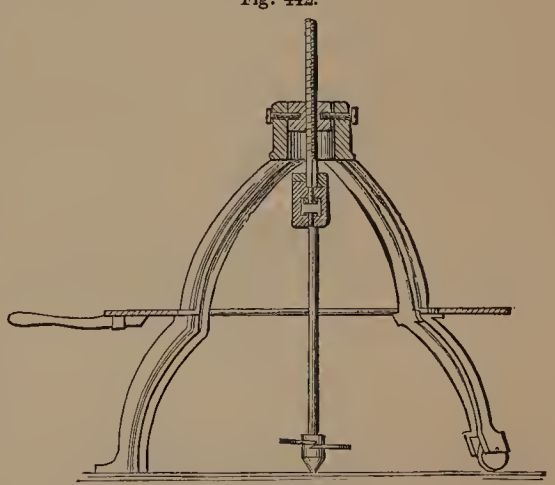
Fig. 441.

Post-Hole Auger.

This raising to dump the load is a general characteristic of post-hole augers, and renders the operation somewhat tedious. The delay has induced arrangements for enabling the tool to hold a large amount of earth, and attempts to make its discharge continuous.

In Fig. 442 the shaft has a point, cutting-lips, and a floor on which the earth is received. It is forced into the ground by the screw on the shank, which rotates in a nut at the junction of the legs of

Fig. 442.

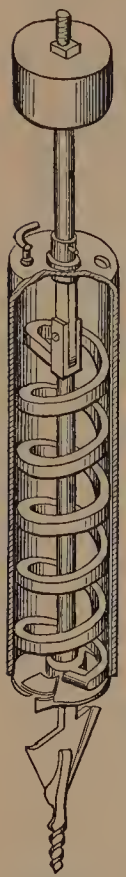


Earth-boring Auger.

the tripod, which is raised above the spot where the auger enters. The end of the screw-shaft is keyed to a stirrup, in which it turns. Above the stirrup is a coupling-piece, having inclined projections fitting in corresponding recesses in the upper part of the stirrup in such a manner that the shaft is made to operate the screw when boring a hole in the ground, and a reverse motion of the shaft will raise the screw out of the ground without turning it.

In Fig. 443 the shaft has a screw point and angular wings, above which is the floor of the dirt-chamber. The soil is scooped up by the usual flange, and is elevated in the chamber by the spiral,

Fig. 443.



McMahen's Earth-boring Auger.

which is braced by the axial rod. The cylindrical case is the measure of its capacity in withdrawing a load.

Other inventions might be cited, but the above represent all the varieties excepting minor differences.

All these are worked by hand, and remove the soil by lifting the tool at intervals from the hole and discharging it. This may be considered the normal character of a post-hole auger.

There are numerous devices for penetrating the ground where the apparatus acts to disintegrate the matter with which it comes in contact: these are called DRILLS, DRIVEN WELL-TUBES, WELL-BORERS, etc., and may be found described under other heads.

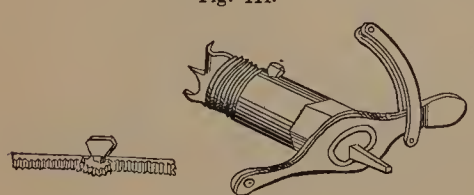
The first is either jarred or rotated to grind its way through soil and rock, and is associated with devices for lifting the detritus by sand-pump, by a stream of water, or by the upward force derived from the concussion of the drill with the rock.

The second consists of a tube which is driven or screwed into the earth, and is generally intended to remain as the permanent pump-tube; for this purpose it has a solid point, to withstand the contact of the obstacles which it is expected to pierce or displace, and holes which are unclosed to admit the water after the wet stratum is reached; these will be explained under their appropriate heading.

The third are devices of a more extensive character than mere hole-diggers, and are used in sinking *Artesian wells*, oil and salt wells, and in boring for mineral lodes.

Au'ger-fau'cet. A faucet with an attached auger, by which the necessary hole is made in the head of the cask. As soon as the auger has about penetrated the

Fig. 444.



Auger-Faucet.

stave, a blow is given to the auger, which breaks away the scale of wood, and the same blow settles the auger into its position. The bit is attached to the faucet, and is projected or retracted by a rack on its shank within the faucet, actuated by a thumb-screw. A frustal projection on the cap affords means for operating the device by a brace.

Au'ger-gage. A device to be attached to the shank of an auger to limit the penetration. The countersinks of some of the compound augers and the sockets of the hollow augers effect the same purpose in some cases.

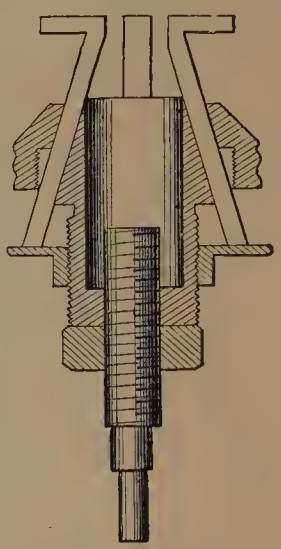
Fig. 445.

Auger-Gage.

The example (Fig. 445) has a pair of bars, secured by temper-screws to the spiral shank, so as to form a gage of depth.

Another form has a telescopic tube attached to the shank, larger in diameter than the worm, and adjusted as to length by means of two temper-screws whose ends bear against the spiral shank.

Fig. 446.



Gage for Hollow Auger.

Fig. 446 is for making tenons of a given length on the ends of spokes, etc., and is adapted for hollow augers. The rear of the stock has a thread traversed by an adjustable screw, which, by contact with the end of the stick, determines the depth of the hole and consequently the length of tenon to be cut. A jam-nut secures the adjustment.

Au'ger-han'dle. The tang of the auger is inserted perpendicularly into its handle, and the end is usually clinched or riveted on to a washer. Means have been contrived for making the auger removable from its handle, so as to make one of the latter answer for varying sizes of augers, and to dislocate the parts for convenience of stowage.

The devices for this purpose consist respectively of a slotted sleeve, a notched key, a nut on the screw-shank, gripping jaws, a spring catch.

Pliny (died A. D. 79) recommends for auger-handles the wood of the wild olive, box, oak, elm, and ash. He says nothing about the augers.

Au'ger-mak'ing Ma-chine'. Augers are made by different processes. They are cast; swaged between dies; twisted as they pass through dies or by the successive motions of the parts of sectional dies; or they are grasped by tongs and twisted by the hands of a skilled workman, and afterwards finished between dies.

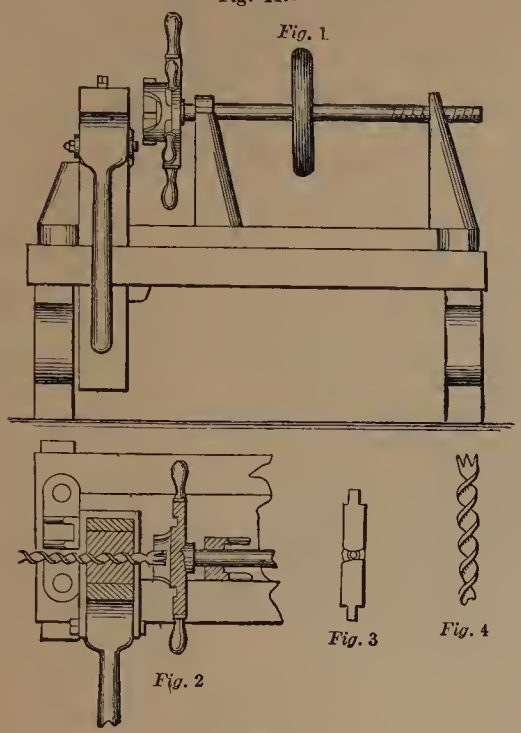
One maker casts the screw-auger in a two-part flask, the pattern of the central shaft and the segmental spirals being so divided as to permit them to be drawn from the sand piecemeal.

Many of the inventions in this line refer to dies of peculiar form, and successions of dies of such form as to cause the blank to gradually assume the shape required. One has a pair of swaging dies, by which the twist is formed either by a succession of blows or by drawing through. The lips are made between dies of the required form, or are bent down by an operation subsequent to the formation of the spiral shank.

Fig. 447 is a machine for turning the lips of augers. The spiral shank is clamped between the jaws with the lips projecting toward the wrench. The latter being advanced, the hub in its center embraces the center point and the lips of the auger. The workman then seizes one of the handles of the wrench-wheel and turns it towards himself, and while the auger is held straight by the engagement of its center point in the axis of the hub, the wrench bends the lips into the required position, the lips being turned simultaneously and their shoulders being left in the same line. Fig. 1 is a side elevation; Fig. 2 a horizontal section; Fig. 3 is a face view of the wrench, and Fig. 4 is a view of the blank before the lips are turned.

In another machine the revolving and longitudinally moving shaft has a transverse slot in its end,

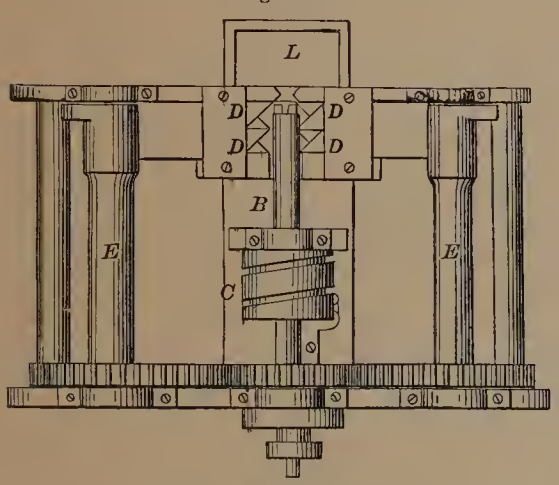
Fig. 447.



Auger-Machine.

in which the flat portion of the blank *A* (Fig. 449) is inserted, the shank being held by a pair of tongs.

Fig. 448.

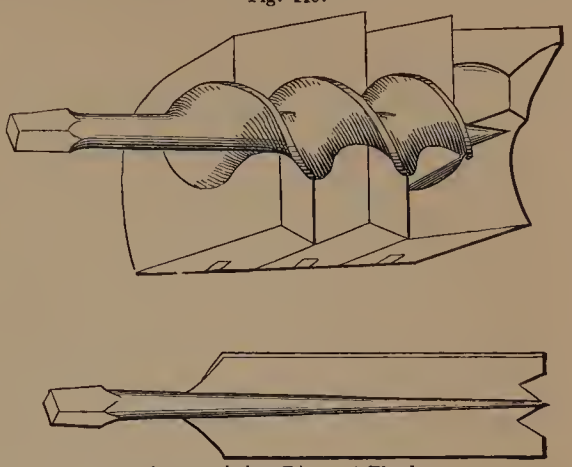


Machine for making Augers.

A series of dies, *D* (Fig, 448), arranged to clasp and hold the auger as fast as it is twisted, completes the process in one operation. The screw *C* on the shaft *B* gives an intermittent longitudinal movement to advance the blank, which is twisted by the continuous rotary movement. *A* (Fig. 449) represents the blank, which is forged or swaged in a drop, and has a longitudinal rib or feather running along its center to insure the requisite stiffness and strength.

The shaft *B* (Fig. 448) is provided with a cylinder *C*, having a screw, or spiral groove, cut upon its surface, with a gaining twist. A pin secured to the frame under the cam works in the grooves, serving as a nut. The shaft, being rotated by the crank or a pulley, is drawn back as it turns by means of the screw-cam. When half a turn is made, the first of the jaws *D D* are forced together by means of the cams on the shafts *E*. The first pair of jaws seize the auger, and, being the exact negative of its twist, hold it firmly and prevent further twisting. The next pair come to their work on the next half-turn, and so on until all the jaws have performed their office, when springs under the jaws force them simultaneously apart as the cams rotate past their centers. It will be seen, by reference to Fig. 449, that the faces of the jaws are dies, exactly corresponding to the twist of the auger.

Fig. 449.

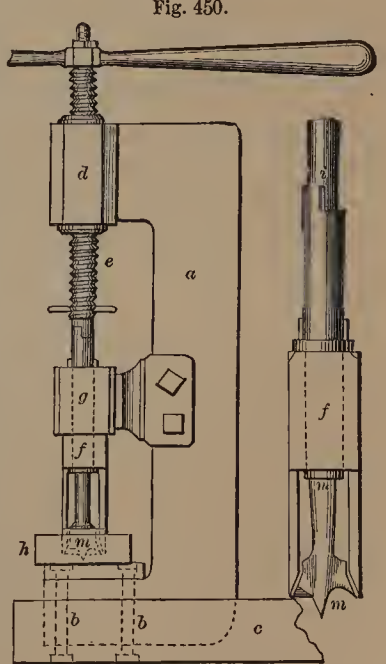


Auger-twisting Dies and Blank.

Au'ger, Square-hole. An auger to cut square holes was described in the Journal of the Franklin Institute, Philadelphia, 1826, as the invention of Mr. A. Branch, of New York. It consisted of a twisted auger operating in a square socket which had a sharp lower edge, and which cut away the margin of the square hole as the auger itself bored a round hole in advance.

HANCOCK'S *Square-hole Borer* (English) was in operation about the same time in London, and operated in a substantially similar manner. *a* is a strong frame, fastened by screws *b* to the bench *c*; *d* is an octagonal socket tapped to receive the vertical screw *e*; to this screw is attached, by a circular tenon and mortise, the square perforating instrument *f*, which slides up and down through a rectangular hole in a brass guide *g* when the screw *e* is turned by the cross-handle at top. The square incision is made by direct pressure downward, at the same time that the center-bit *m* cuts out a round hole, the chips rising up and passing out at

Fig. 450.



Hancock's Square-hole Auger.

the two open sides of the square cutter. *h* is a piece of wood being bored.

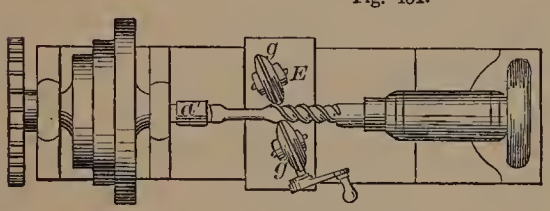
The detached auger is shown on a larger scale; the tenon *i* is inserted in a cavity in the screw *e*, and made fast by a cross-pin which goes through both. This arrangement allows a ready substitution of augers of different sizes. The lower extremity of the revolving portion holds the center-bit *m*, which, owing to the collar *n*, cannot ascend or descend without the square cutter which cuts out the angles beyond the range of the circular borer.

The square-cutting tool is a bar of steel with a round hole drilled out of the solid, and the edges are formed by filing and grinding them to the bevels, shown in the enlarged figure.

MERRITT'S *Machine for boring Angular Holes*, May 24, 1864. The holes are bored by rotary cutters; fixed, and reciprocating in a plane at right angles to the axis of the hole. The relatively fixed auger makes a round hole, as usual; certain cutters which partake of the circular motion have also a reciprocation towards and from their axis of rotation, being projected outward and again retracted four times in a rotation, to cut out the angles left by the round auger, thus making a square hole. See BORING-MACHINE.

Au'ger-twist'er. A machine for giving the twist to blanks for screw-augers. There are many

Fig. 451.



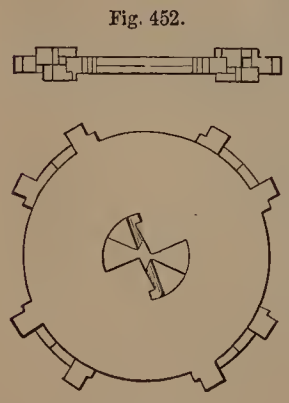
Auger-Twister.

forms of machines for this purpose; in one the blank is pressed between rolls upon a slide-rest, which are drawn together by a hand-screw. The blank is twisted simultaneously with the action of the rollers *g g*.

The twist is regulated by the rate of longitudinal motion of the rest *E* upon the ways of the lathe, relatively to the rate of revolution of the front center *a*, which carries the blank. The degree of proximity of the rollers *g g* is determined by the right and left screw *J*, which gives an adjustment of the carriers *G* on the rest *E*. The screw *J* is operated by the hand-crank shown in the plan-view.

In another form the auger-die consists of a series of pairs of circular metallic plates, superimposed on each other, each plate having a peculiarly shaped mortise through the center, and provided also with projecting and overlapping studs upon its periphery. When these plates are arranged so that all the mortises are in line, they admit the flat bar of heated metal, which forms the auger-blank. The upper plate is then revolved, and after a certain extent of motion its stud engages the one below it, which is moved to a corresponding extent, and the action is imparted to each disk in consecutive order, bringing the flat blank into a regular spiral. The opening of the disk-sections releases the auger.

Fig. 452.



Auger Die.

Au-get'; Au-gette'. (*Mining.*) A priming-tube connecting the charge-chamber with the gallery, or place where the slow-match is applied.

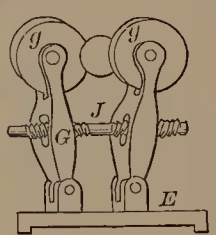
Au'ral In'stru-ments. See ACOUSTIC INSTRUMENTS.

Au'ri-cle. An artificial external ear, made of gutta-percha, bleached and colored. Retained by hand or clasp.

Auricles consist of two trumpets shaped like ram's horns, and connected by an adjustable spring passing over the crown of the head. They are flattened on one side in order to fit closer. The mouth-piece, being above the ear, is pointed forward; the neck, passing back and downwards close to the ear, tapering towards the ear-piece, which is made of soft rubber or ivory. They are easily concealed, especially by ladies, who can dress their hair over them.

The interior ear is furnished with the means of dealing with the three characteristics of sound: its typanum, for intensity; its cochlea, for pitch; its semicircular canals, for quality.

Au-ric'u-lar Tube. A speaking-tube; either portable for the use of deaf persons, or between stories, apartments, or parts of an apartment, for the conveyance of messages.



Au'ri-lave. An ear-brush.

Au'ri-scalp. An instrument for operating upon or cleaning the meatus auditorius.

Au'ri-scope. (*Surgical.*) An instrument for ascertaining the condition of the Eustachian passage.

Au'rum ful'mi-nans. Fulminate of gold. A powder of gold and aqua regia. So called from the report it makes when exploded by percussion or attrition.

Au'rum mu-si'vum. Sulphuret of tin, used as a bronze powder.

Aus-cul-ta'tion In'stru-ment. An instrument for the purpose of distinguishing diseases of the viscera by observation of sounds in the part affected. It is particularly applied to the thorax. See STETHOSCOPE; PLEXIMETER, etc.

Au'tho-type. A type or block containing a fac-simile of an autograph. Such are or were used for franking official envelopes, signatures to routine correspondence, and as labels to prevent fraudulent imitations of the contents of the package.

Au-to-chro'no-graph. An instrument for the instantaneous self-recording or printing of time.

Au'to-clave. A French stewpan, with a lid ground on, steam tight. The lid is clamped down on its seat by twisting it round under ears on the side, or by means of a bail and screw, a gasket of linen being used. It is a form of Dr. Papin's digester, and should have a safety-valve. See DIGESTER.

Au-to-dy-nam'ic El'e-va-tor. One in which the weight of a falling column of water is made to elevate a smaller column to a hight above the source; and in which the changes of the valves are automatically produced.

Such are water-rams, the fountain of Hero, etc. See WATER-ELEVATOR.

Au-to-ge'ne-ous Sol'der-ing. The junction by fusion of the joining edges of metals, without the intervention of solder. The edges, being brought together and brightened, are held under a jet of

burning gas urged by a blow-pipe, which melts the edges so that they run together.

Au-to-graph'ic Ink. Ink suitable for transferring to stone, writings or drawings executed in it upon prepared paper. Transferring ink.

Dry soap	100
White wax	100
Mutton suet	30
Shellac	50
Mastic	50
Lampblack	30

melted, and worked into an ink.

Au-to-graph'ic Pa'per. Paper prepared to receive a drawing or writing in a suitable ink, and to part with the same to the surface of the lithographic stone or zinc plate, in the process of transferring. The paper is covered with size, which resists the penetration of the ink into the paper. The drawing or writing is executed on the sized surface, so that when the paper is damped it may become detached from the ink, instead of carrying some of the ink away with it, as it would do if the ink were allowed to be partially absorbed by the paper. The size is made of

Starch	120
Gum-arabic	40
Alum	21

This is spread on the paper, which is then dried and pressed.

Or, for transfer of writing to stone, lay on the paper three successive coats of calves'-foot jelly, one layer of white starch, one layer of gamboge. Allow each to dry before applying the next. Smooth by passing through the lithographic press. Write on the gamboge surface. In transferring, damp the paper, place the ink-surface on the stone, and run it through the press. The ink leaves the gamboge surface and adheres to the stone.

A very fair transfer may be obtained from a good quality of writing paper.

Au-to-graph'ic Press. A portable printing-press for taking impressions of autograph signatures from a lithographic stone, or form of type.

Au-to-graph'ic Tel'e-graph. Invented by the Abbé Caselli. An instrument for transmitting autographic communications, accomplished by the aid of two pendulums having a movement absolutely synchronous. One of the pendulums carries a pen or pencil of fine platinum wire, in connection with the line and the line battery, over the surface of the dispatch previously written in insulating ink upon a metallic paper. The other pendulum, at the corresponding station, carries an iron pencil, likewise in connection with the line, over a paper prepared with a solution of the yellow cyanide of potassium. The electric circuits are so disposed, that when the platinum point in its passage over the original writing touches the metallic surface of the paper, there is no emission of current along the line; while, on the other hand, when the point touches the insulating ink, an emission of current takes place, and the iron point passing at the other end of the line over the prepared paper leaves on it a blue mark. The movement of the two pendulums being precisely equal, the reproduction of the dispatch is absolutely exact.

The same apparatus has been made to transmit portraits executed in insulating ink upon metallic paper.

Au-to-mat'ic Fire. The automatic fire or explosive mixture of the Greeks was made from equal parts of sulphur, saltpeter, and sulphide of antimony, finely pulverized and mixed into a paste, with equal parts of the juice of black sycamore and liquid asphaltum, a little quick-lime being added. The rays of the sun would set it on fire. — DRAPER.

Au-to-mat'ic Lamp. A lamp used by dentists in the operation of vulcanizing. When properly adjusted, the flow of gas or alcohol is arrested by a spring cut-off, released by the breaking of a fusible alloy, and extinguishing the flame when the heat reaches a point slightly above that required to finish the process of vulcanizing.

Au-to-mat'ic Mal'let. A tool used by dentists in plugging teeth. There are several forms, but they agree in the delivery of a blow by pressure of the tool on the filling of the tooth cavity. See DENTAL HAMMER.

Au-to-mat'ic Valve. A valve operated by the fluid in progress, in contradistinction to one operated by the positive action of a part of the machinery.

Au-tom'a-ton. A machine whose motive-power is concealed within itself, or, as the term is more generally understood, a machine which imitates the actions of men or animals, and, being moved by clock-work or other similar instrumentality, *appears* to perform certain acts by its own volition. Among the most remarkable of antiquity were the automatons of Hero of Alexandria, who flourished about 217 B. C. They were made to move, as if alive, by machinery under the floor, and to utter sounds by the action of air driven by water through small pipes, or by means of air rarefied by heat. His works are extant in Greek, and have been frequently translated. They contain many curious anticipations of modern devices, as well as many curious tricks and effects no doubt intended as a part of the machinery of the priests to amuse the speculative and astound the ignorant. Archytis's flying dove was made about 400 B. C. Friar Bacon's speaking head, 1264 A. D. An automatic coach, horses and passengers, was made by Camus for Louis XIV. when a child. Vaucanson made an artificial duck which quacked, ate, and drank; its food undergoing a change simulating digestion. Vaucanson also constructed a flute-player, 1738. The writing automaton was a pantograph, deceptively worked by a confederate, 1769. The automaton chess-player was also a deception, 1769. Maelzel made a trumpeter in 1809. An automaton speaking several sentences was exhibited in London about 1810. See Brewster's "Natural Magic."

The speaking machine invented by a Viennese, exhibited in Europe many years since, and lately in this country, is not an automaton, but is played by keys. The thorax is a bellows, and the sounds are made by the passage of air past reeds which simulate the larynx, and modulated by artificial tongue, palate, teeth, and lips.

The drawing automaton constructed by M. Droz, of the Chaux de Fronds, was a figure of a man the size of life, operated by clock-work and springs, and capable of executing six different drawings. It used a metallic style, and drew on vellum. The transitions from one point to another were done by lifting the style, without slurring. It is fully described in Dr. Hutton's Mathematical Dictionary.

M. Malliardet's writing automaton executed four pieces of writing in French and English. It was the figure of a boy resting upon one knee and drawing with a pen upon paper laid on a brass tablet. The writing consisted in each case of several lines, and, after finishing each line, the figure returned to the beginning of the line to dot and cross the letters. The hand has two horizontal and one vertical motion; the down strokes of the pen were made relatively thicker by an increase of pressure.

The annexed engraving is a fac-simile of a drawing executed by the automaton of M. Droz.

Fig. 453.

Cupid.

Au-tom'a-ton Bal'ance. A machine for weighing planchet or coin, automatically sorting the pieces into *full* and *light* weight, respectively. See COIN-WEIGHING MACHINE.

Au-tom'e-ter. An instrument to measure the quantity of moisture.

Au'to-phon. A barrel-organ, the tunes of which are produced by means of perforated sheets of mill-board.

Au'to-phyte Rib'bon. A Swiss ribbon printed by zinc plates which have been produced by the photozinco process from a real lace original.

Au'to-type. A phototypic process. The gelatine is whipped into a froth with warm water and sugar, skimmed, cooled, cut into blocks, and mixed with the pigments. To this creamy fluid the sensitizing agent, bichromate of potash, is added, and the liquid is conveyed to a trough in a room with orange-colored curtains, where a traveling sheet of paper is covered on one side with the compound. The tissue with its coat of sensitive varnish is then dried, and a piece of the required size is exposed to the sun's rays in connection with a collodion negative obtained in the ordinary manner. The required time having elapsed, the tissue is taken out of the case and plunged into cold water with its face downwards on a plate of glass, metal, or another paper, coated with a light solution of gelatine and chrome alum. The surfaces having united, the whole is plunged in a bath of hot water, when the parts of the composition not hardened by the action of the light are dissolved, and the paper slips off, the tougher parts remaining attached to the plate, and successive rinsings remove the cloud of colored gelatine until the picture is free. This is the Swan process of *Carbon Printing* (which see).

The next step is to prepare the "plate" for the printing-press. This consists of a mode of mounting the carbon-print upon a substratum of similar material backed by a glass or metallic plate, so that the picture may be used as a printing surface. A mixture of gelatine, albumen, and bichromate of potash is mixed and filtered. A sheet of plate-glass, about half an inch thick, is then leveled in a drying-box, warmed up to a temperature of 100° Fahrenheit, and coated with the preparation. In about two hours the first coating is dry. The second coating consists of gelatine, albumen, and bichromates, with the addition of a small quantity of an alcoholic solution of resinous gums; to this is added a *soupçon* of nitrate of silver with a few drops of a solution containing an alkaline iodide. After washing out the excess of bichromate from the first coating, the second preparation is applied to the plate, which is again subjected to a high temperature in the drying-box, and becomes thoroughly dry and ready for use in two or three hours. The tough "negative" film is then laid down upon the plate-glass of the pressure-frame, and the plate, now completely coated with a sensitive surface, is laid upon it. The whole is exposed to the sunlight, and the progress of the printing can be easily ascertained by looking through the plate from the back. After exposure, the plates are well washed in cold water, rinsed thoroughly, and allowed to dry; they are then ready for the press. Subsequent operations depend upon two simple truths: first, that the gelatinous film will absorb water; and, secondly, that any greasy mixture of the nature of printer's ink, or any pigment prepared in like fashion, abhors the contact of water, and absolutely refuses to adhere to those portions of the plate which have absorbed that fluid. The success of the operation does not depend upon the relief of the plate, but on the faculty of gelatine for absorbing water, and then, as a matter of course, resisting the imposition of a fatty ink. See HELIOTYPE.

Au'to-ty-pog'ra-phy. Invented by George Wallis, London.

By this method drawings are so executed that they can afterwards be impressed into soft-metal plates. The drawings are executed preferably on gelatine with a peculiar material which is salient and makes a sunken impression in the plate against which it is driven by passing between a pair of rollers.

The resulting plate is printed from as an ordinary copperplate. See also MOLDING FROM PERISHABLE OBJECTS; NATURE-PRINTING.

Aux-il'ia-ry or Feed'ing En'gine. Is fitted to supply tubular boilers with feed-water when the large engines are not working and the ordinary feed-pumps are therefore inactive.

Aux-il'ia-ry Screw. A screw in a fully masted vessel; used in calms, working to windward, or in emergencies. It is so rigged as to be unshipped when not in use.

A-vant'-fosse. (*Fortification.*) A ditch at the foot of the glacis.

A've-ler. A machine for ridding the grains of barley of their *awns* or *avels*. A HUMMELING-MACHINE, which see.

A-ven'tu-rine. A fancy glass of a brownish color with gold-color spots, produced by small fragments of copper and iron in the mass.

A-ven'tu-rine Glass. This ornamental glass is used for weights and ware, the filings of metal giving a spangled appearance; in imitation of a resplendent variety of feldspar, whose color arises from imbedded minute lamellar crystals of oxide of iron.

It is prepared by fusing together for 12 hours a mixture of 300 parts pounded glass, 40 parts of copper scales, 80 parts iron scales, and cooling the mixture slowly.

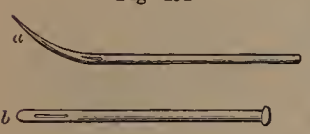
A-ver-un'ca-tor. A long name for a pruning-shears with a long handle, to which the fixed blade is attached; the movable blade is operated by a cord and reopened by a spring. It makes a *draw-cut*. See PRUNING-SHEARS.

Awl. A pointed, piercing instrument in common use and of great antiquity. It is evidently older than the needle, which has not yet superseded its use, though it has supplanted it in ordinary sewing. The hides which covered the osier framework of the coracle of the ancient Briton, and the birch

bark which covers the canoe frame of the Chippewa Indian, were and are sewn into place by means of an awl, which opens the way for the thong or deer-sinews. The awl is referred to in Exodus xxi. 6, and Deuteronomy xv. 17, where a Hebrew servant who refused to leave his master when his sixth year of bondage was completed, was brought to the door-post and his ear bored through with an awl, after which he became a slave for life. The Egyptian awl of the time of Thothmes III., contemporary with Moses, is shown in a Theban tomb. The pointed instrument was placed in a nearly spherical handle, to fit the palm of the hand. An awl differs from a needle in this, that one is attached to a handle and is retracted, while the other passes through the article and carries the thread which is attached to it.

The sewing-machine needle, so called, is really an awl, except in that small class where the needle and its attached thread are driven through the fabric, making a running stitch (Smith's, Dales's, and others). In many kinds of goods and materials it would seem so much better to have the awl provided with an eye near the end, that it is singular it did not come into general use for sewing machines many years back. The idea was not new, for in the needles used in packing hampers (*a*, Fig. 454) the eye was placed near the point as in a bodkin, *b*, and the twine was pushed through between the meshes of the lid and the basket, so that it could be grasped by the hand without pushing the needle clear through. The upholstery needle and thatching-needle are ancient and eye-pointed.

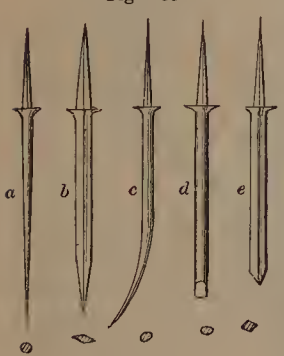
Fig. 454.



Packing-Needle and Bodkin.

The eye-pointed needle was one of the principal claims in the patent of Elias Howe, Jr., which netted him so large a fortune, and which, originally granted in 1846, was made by an extension to last to 1867.

Fig. 455.



Awls.

Awls vary in shape with the purposes for which they are intended, The round awl tapered to a point, *a*, is used for a marker or scratch-awl. The awl of a diamond shape, *b*, is used by harness-makers to form an opening for the needles which carry the threads. The round-shanked, bent-ended awl, *c*, is used by shoemakers to make a curved channel, which is followed by the bristle forming the point of the wax-end. The brad-awl, *d*, is used by carpenters to form an opening for brads, etc. It has a cylindrical shank, sharpened to a chisel-edge at the end. The awl *e*, used by wire-workers, is square, and sharp on all four edges; its shape renders it less liable to split the wood.

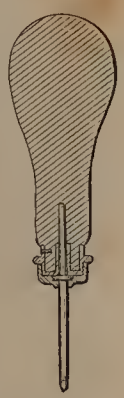
Fig. 456.

Sewing-Awl.

The sewing-awl (Fig. 456) is used by workers in leather.

The pegging-awl is straight, and is strong enough to drive into wood. The ferrule on the end of the handle is provided with a hollow shank made square. On the outside of the shank is a screw-thread, over which screws a cap having a hole for the insertion of the awl. The flange of the awl is nipped between the cap and head of the ferrule and firmly secured.

Fig. 457.



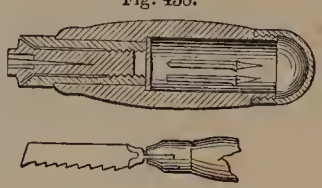
Pegging-Awl.

In one form of pegging-awl the socket gripping the awl is surrounded by a sleeve, which is projected by a spiral spring within the handle, so as to assist in extracting the awl by pressing upon the leather.

A convenient kit of small tools inclosed in a handle is shown in Fig. 458. The serrated shank of either tool is clasped in the gripper as the latter is screwed into the socket. A receptacle in the large end holds the tools.

The awl-handle in Fig 459 is a locking pliers, whose jaws are adapted to hold either of the tools; those not in use are inclosed in the hollow handle when the latter is closed. A boss on the end of the handle forms a hammer. The figure shows an elevation, open; and a section, closed.

Fig. 458.



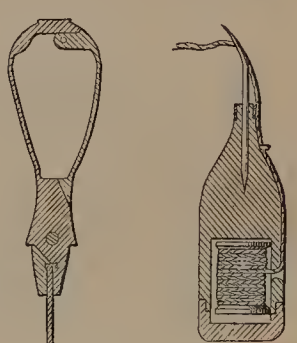
Awl and Tools.

In Fig. 460 the eye-pointed awl introduces the thread, which is fed from a spool concealed within the handle.

Fig. 459.

Awl-Handle.

Fig. 460.



Lasting-Awl.

Awn'er. A machine for taking off the *awls* or *awns* of barley. See HUMMELING-MACHINE.

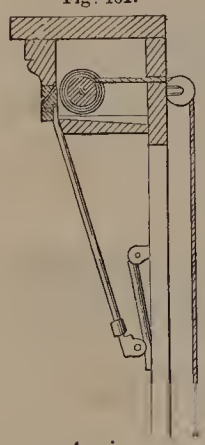
Awn'ing. A shield or shade for protection from the rays of the sun; usually attached to buildings, and especially to protect store-fronts and add to the comfort of pedestrians. The ordinary mode of supporting a roll of canvas, by means of rafters resting against the building and upon posts at the curb, need hardly be described. The canvas is tacked to a roller and is furled by means of a running rope, being protected, when furled, by a pent-roof on the wall of the building.

So far as ingenuity has been exercised upon this subject it has generally been upon modes of lowering and winding, having especial reference to shading sidewalks and show-windows. Some devices, however, have been intended for window-shades, and are modified in shape and mode of operation to suit their location.

Awnings of *linen* were first used by the Romans

in the theater, when Q. Catulus dedicated the Temple of Jupiter, B. C. 69. After this, Lentulus Spinther is said to have first introduced *cotton* awnings in the theater at the Apollinarian Games, July 6, B. C. 63; they were red, yellow, and iron-gray. By and by, Cæsar the Dictator covered with awnings the whole Roman Forum, and the Sacred Way, from his own house to the ascent of the Capitoline Hill; this was 46 B. C., and is said to have appeared more wonderful than the gladiatorial exhibition itself. Afterward, without exhibiting games, Marcellus, the son of Octavia, sister of Augustus, when he was ædile and his uncle consul the eleventh time, on the day before the Kalends of August, July 31, 23 B. C., protected the Forum from the rays of the sun, that the people engaged in lawsuits might stand with less injury to their health. Pliny says: "What a change from the manners that prevailed under Cato the Censor, who thought that the Forum should even be strewed with caltrops!"

Fig. 461.

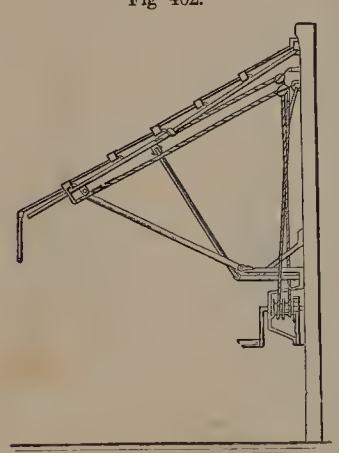


Awning.

The awnings extended, by the aid of ropes, over the amphitheater of the Emperor Nero, were dyed azure like the heavens, and bespangled with stars. The *atrium*, or hall of audience, of the Roman houses, had an opening in the middle, which was covered in summer with a red awning.

In Fig. 461 the awning is rolled upon a shaft having permanent bearings in the box which assumes an architectural form in the entablature of the shop-front. The hem of the awning is fastened to a bar, which, when closed, forms the architrave, but which swings open when the awning is unfurled from the roller in the box, and is supported by jointed extension-bars from the pilasters of the store-front. As the awning unwinds, the hoisting-rope coils on the roller, and becomes the means of refurling.

Fig 462.



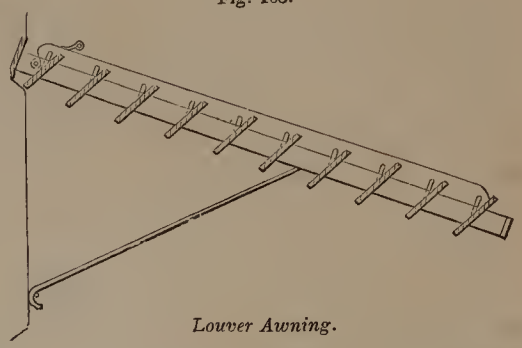
Metallic Awning.

In Fig. 462 the metallic plates which form the awning are arranged to lap one over another, each plate being fitted between guides, which are attached to the lower end of the plate immediately above it. The plates are connected to toggles, which are operated by arms and a windlass, to raise and fold the plates, or to distend them into effective position.

In the Louver awning each slat of the awning is pivoted in the rafter, and is connected by crank-arms to a bar which is operated by cords, so as to act, like a Venetian shutter, upon all the slats simultaneously and exclude the direct rays of the sun, while permitting a diffused or reflected light to enter the store.

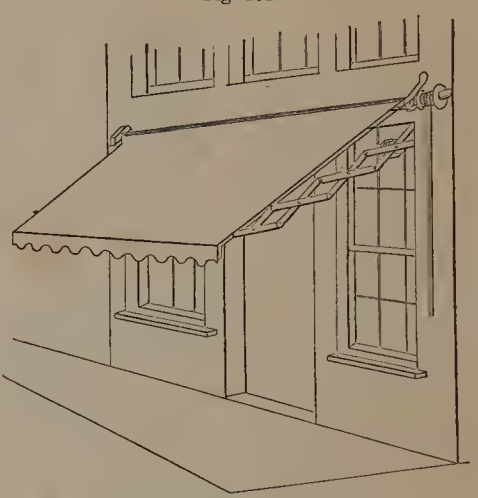
In another form the light wooden slats of the awning fold over each other like the leaves of a fan. The slats are arranged on a suitable frame, and there are two pulling cords, one of which spreads the awning and the other folds it up.

Fig. 463.



Louver Awning.

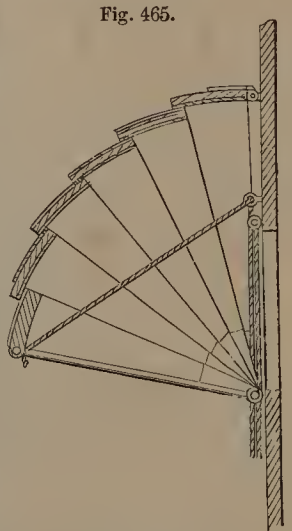
Fig. 464.



Lazy-Tongs-Extension Awning.

In Fig. 464 the lower edge of the awning is attached to the boards, which are secured to the side extensors. The extensors are made in toggle-sections, operating as lazy tongs. The upper edge of the awning is coiled on a roller operated by a cord; it is held by a pawl, to keep the canvas stretched. The spiral spring acts to keep the arm extended.

Fig. 465.



Arched Awning.

Fig. 465 shows front and tapered side-slats, which slide one beneath the other, being connected together by plates with headed studs, which work in slotted plates affixed on the adjacent slats.

The end-slats collect like the folding parts of a fan; the roof-slats take position in vertical parallel series when closed.

Axe. A chopping and felling tool. It has an eye by which it is attached to the helve. The edge is in the plane of the sweep of the tool; it therein differs from the adze.

Pliny, who wrote about A. D. 50, felt bound to state an inventor for everything, and ascribed the invention of the axe to Dædalus, of Athens, about 1240 B. C. It is, however, to be supposed that

when Cecrops, three hundred years before, forsaking Egypt and leaving civilization behind him, landed in Greece, he had axes wherewith to clear a spot for the village he founded.

About the year 1093 B. C. we read that the Hebrews went to Philistia "to sharpen every man his axe" (1 Samuel xiii. 20); and about 893 B. C. "the axe-head fell into the water" while the man was chopping (2 Kings vi. 5). Previous to these two latter dates, and two hundred years before the time of Dædalus, we find that the Mosaic law, 1451 B. C., had anticipated the following supposed case:—

"As when a man goeth into the wood with his neighbor to hew wood, and his hand fetcheth a stroke with the axe to cut down the tree, and the head [Hebrew, *iron*] slippeth from the helve, and lighteth upon his neighbor that he die, he shall flee unto one of those cities [of refuge] and live."

In Deuteronomy xx. 19, it is forbidden to "force an axe" against the fruit-trees of a besieged city, 1451 B. C. Later, so valuable was skill in the use of this tool, we learn that "a man was famous according as he had lifted up axes upon the thick trees" (Psalms lxxiv. 5).

The axe has a cutting edge of steel attached to a wrought-iron head, which has an eye parallel to the chord of the curved cutting edge. It is found among all nations who have the material and skill for its manufacture, the substantial form having descended from the stone age, when a withe or elastic handle was bent around a circular depression on the head, and the edge was sharpened to the extent the constitution of its material would bear, or according to the means at hand for dressing it; as in the case of chipping an edge on a flint hatchet.

Fig. 466.

Primitive Axe.

The accompanying cut represents a stone axe of highly polished, dark greenstone, found within a primitive canoe, at a depth of 25 feet below the surface of the ground, in the Valley of the Clyde, Scotland. The canoe was hewn out of a single oak, and was exhumed from beneath the site once occupied by an ancient church. This axe is exactly like a number which have been recovered from the mounds and fields of the West. It is the same weapon termed a *celt* by archæologists.

The axes, fasces, trumpets, sacrifices, divination, and music of the Romans were introduced from the Etrurians. Auger and oracle still exist in the land of their adoption.

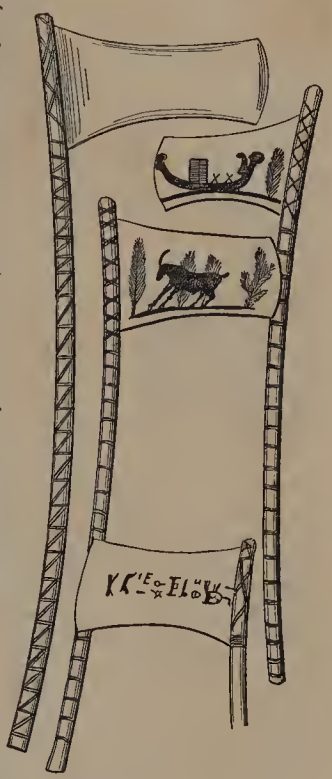
The mention of the axe (ἀξίμη) occurs frequently in Greek authors. A crooked one for shipbuilders, and a double-bladed one for a weapon, are also mentioned. The English word *stale* for an axe-helve is derived from the Greek.

The Roman *bipennis* was a double-bladed axe with the eye in the center, like some of our modern ones. See DOUBLE-BITTED AXE.

The Egyptian axe was of iron, steel, or bronze; the color seems to indicate the former metal in some cases, but it was generally of bronze. The handle was split to receive the blade, which was secured by bronze pins and leather thongs. It was used as a weapon in felling timber, shivering gates, etc.

Figure 468 shows three Egyptian axes. The larger one belonged to Salt's collection, and is now in the British Museum. The blade is of bronze, 13½ inches long and 2½ inches broad. It is secured by silver pins in a tube of the same metal. The tube was adapted to contain a wooden handle.

Fig. 467.



Egyptian Axes (Thebes).

The other figures are of axes from Thebes.

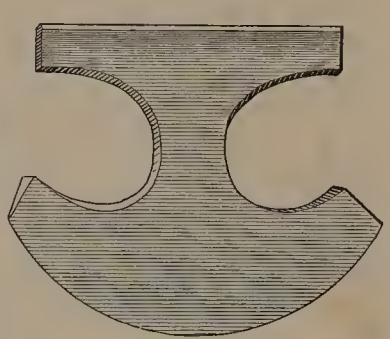
The Peruvian axes, chisels, knives, and awls were made of an alloy of copper and tin. The bits of their axes were about the same shape as ours, but the heads were inserted in the handle instead of the handle in the axe-head. Iron was unknown among them. Tin, added in certain proportions to the copper, gives it the hardness of steel. See ALLOYS: ANNEALING.

Copper axes with single and double bits have been found in a *tumulus* near Chillicothe, Ohio. A small hole through the middle of the two-edged axe indicates that it was secured to the helve by lashing.

Fig. 468.

Egyptian Axes

Fig. 469.



Peruvian Knife or Axe.

The single-bitted axe is solid and well hammered, and weighs two pounds five ounces. It is seven inches long and five broad at the cutting edge, having an average thickness of two fifths of an inch. Its edge is slightly curved, after the manner of modern axes, and it is beveled from both sides. Copper chisels, gravers, etc., are also found in the American mounds.

Lubbock states that the bronze axes, of the ages when that metal predominated, were all destitute of eyes for the handles.

The following are various kinds of axes:—

Barking-axe.
Battle-axe.
Bill-hook.
Brick-axe.
Broadaxe.
Cavil.
Chip-axe.
Cleaver.
Double-bitted axe.
Felling-axe.
Grubbing-axe.
Halberd.

Hand-axe.
Hatchet.
Jedding-axe.
Machete.
Pickaxe.
Pole-axe.
Side-axe.
Slate-axe.
Stone-axe.
Tomahawk.
Zax.

See these in their alphabetical places in the body of the work.

The *felling*-axe of the artillery is of the following dimensions : —

Length,	7.25 inches.	
Width of top,	3.50 "	
" " edge,	4.75 "	
Thickness at top,	0.75 "	
" " eye,	1.25 "	
Size of the eye,	2.25 "	× 0.75 inches.
Handle (hickory),	27. "	long.
Weight,	6 pounds.	

In the most recent process for making axes, hammered bar-iron is heated to a red heat, cut off the requisite length, and the eye, which is to receive the handle, punched through it. It is then reheated and pressed between concave dies until it assumes the proper shape. It is now heated and grooved upon the edge to receive the piece of steel which forms the sharp edge. To make the steel adhere to the iron, borax is used. This acts as a soap to clean the metal in order that the parts may adhere. At a white heat it is welded and drawn out to a proper edge by trip-hammers. The next process is hammering-off the tool by hand, restoring the shape lost in drawing out ; it is then ground, to form a finer edge. Afterwards it is ground upon finer stones, and made ready for the temperer. The axe is now hung upon a revolving wheel in a furnace over a small coal-fire, at a peculiar red heat. It is cooled successively in salt and fresh water, and then tempered in another furnace, where the heat is regulated by a thermometer. It is then polished to a high finish, which will show every flaw and enable it to resist rust. It is then stamped, and the head blackened with a mixture of turpentine and asphaltum.

Axes have been made partly of iron and partly of steel, or of different qualities of steel, by pouring into a mold first one of these metals in a molten state, and then the other metal, thus superseding welding. The steel portion is cast thick in the first place, and then drawn under the hammer.

Axes are *cast*, *rolled*, swaged between dies, or forged with the hammer.

The portions of an axe are known as the *bit*, *poll*, *eye*, and *head*.

Inserting a steel *bit* in the cleft *head* is known as *steeling*, and thus are axes refitted when the old head is worthy of such repair.

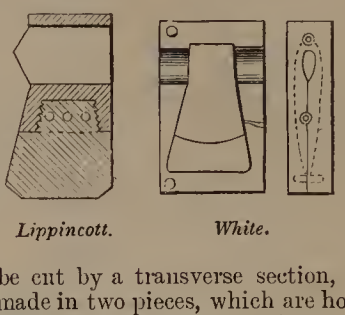
Fig. 470 shows an axe with a head of iron, cast into and around a steel bit, previously inserted in the mold. The axe is then finished and dressed.

The axe (Fig. 471) is made by pouring steel from a crucible into a mold, a core maintaining the shape of the eye.

In Fig. 472 the steel is bent and lapped around the edge of the iron portion to which it is welded, instead of being inserted in the split edge of the axe-head, — an inversion of the position.

The continuous blank, from which axe-heads may

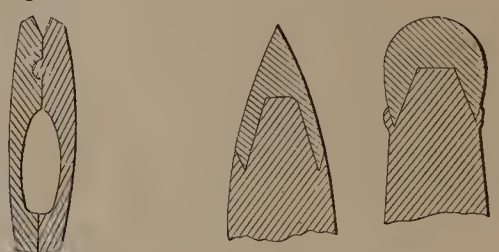
Fig. 470. Fig. 471. Fig. 472.



Lippincott. *White.* *Mann.*

be cut by a transverse section, is made in two pieces, which are hollowed to form the eye, and have a matching bead and groove to fit the portions together. The transverse section (Fig. 473) shows the shape of an axe without the steel, which is subsequently inserted into the notch and secured by welding.

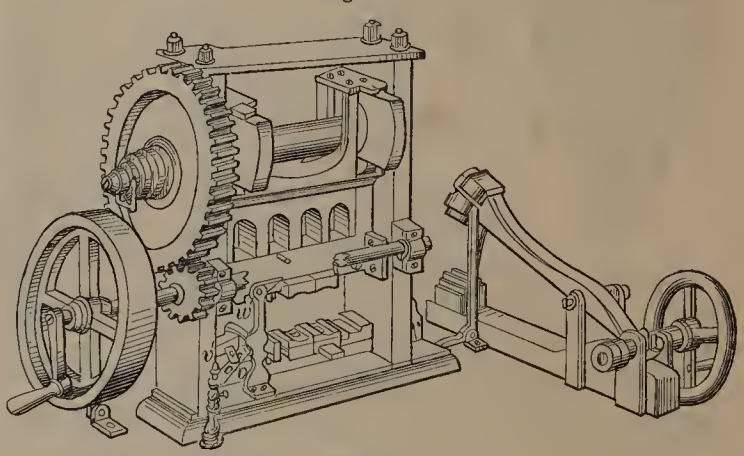
Fig. 473. Fig. 474.



Axe-Blank. *Lippincott.*

The bifurcated edges of the steel bit in the example (Fig. 474) are inserted into a scarf on each side of the stock, which is thus made to lap over the bit, and is welded down thereon, as in the left-hand figure.

Fig. 475.

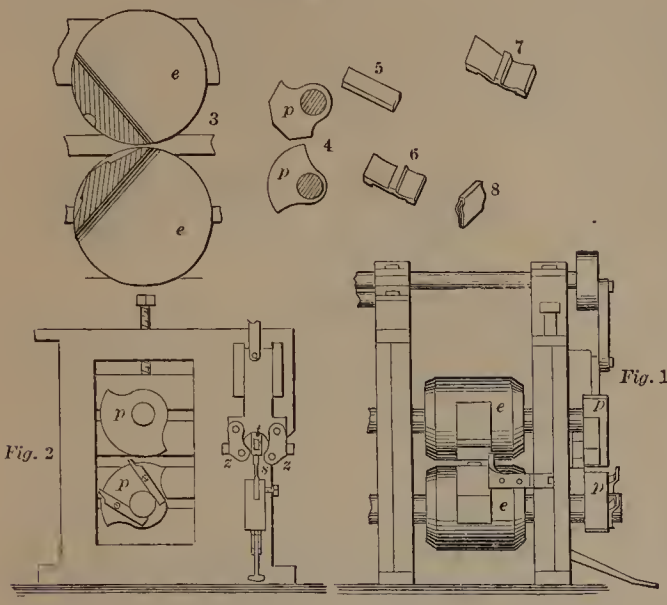


Axe-Machine.

In the axe-making machine (Fig. 475) a series of dies are arranged in the bed beneath and the reciprocating block above. They cut off the blank for the axe-head, and shape and weld it while being held between the dies by means of a mandrel in the hands of the attendant. At the side of the machine is a punch for trimming the eye and a trip-hammer with suitable dies for trimming the head. The axe under treatment is moved from one operative part of the machine to another, and swaged to form by successive blows.

Fig. 476 represents a machine in which the axe is made by successive operations between dies.

Fig. 476.

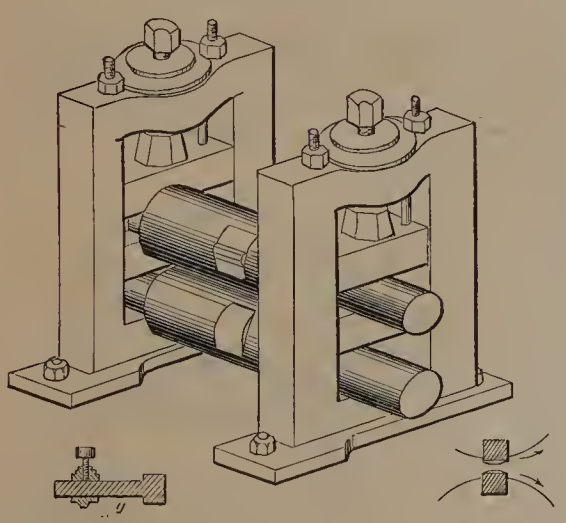


Hutchins's Machine for making Axes.

In this illustration, Fig. 1 is a front elevation; Fig. 2 is a side view of the dies *p p*, and Figs. 3 and 4 are sections of the dies. Fig. 5 is the iron blank. Figs. 6, 7, and 8 are the shapes it successively assumes as it comes from between the roller-dies *e e* and *p p*, and the bending apparatus *z s t*. The dies, by successive operations, give it the proper shape on both sides; it is then placed on the upper face of the *former*, which corresponds to the inner surface of the eye. The head is gripped by the jaw, which is depressed by a treadle; the carriage is depressed by the crank-rod, and the rollers *z z* bring the iron to shape.

In the machine (Fig. 477) the axe-heads are manu-

Fig. 477.

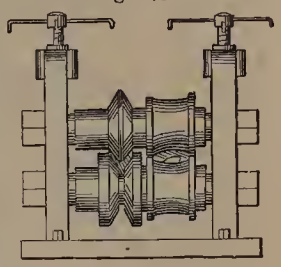


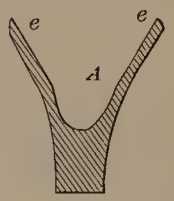
Axe-Blank Machine.

factured by compressing only one half thereof, at each operation, between dies or swages of the required shape projecting from the face of the rolls in which they are set, so that the axe-head can be inserted and withdrawn without coming in contact with the rolls; the adjustable guide *g* is either attached to the dies or separate therefrom, for the purpose of applying the pressure necessary to form the axe-head, in such a manner as to leave any excess or deficiency of iron in the poll of the axe-head, thus securing exact uniformity in the two sides thereof, and enabling axes of various sizes to be made from the same dies by simply adjusting the distance of the rolls and the gage.

In another machine the end of a heated bar is inserted into the machine; the blank cut off; the eye punched by oval punches, while the blank is held and compressed by the movable sections of the die-box, one of whose sides is sharp-edged to open the blank for the insertion of the steel bit.

Fig. 478.

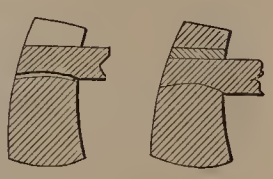




Axe-Blank Machine.

Fig. 478 splits and opens a long bar, so that it may be cut up into axe-blanks ready to receive the steel bit. The upper part of the figure shows two runs of rolls, one for rounding and the other for splitting. The lower figure shows the split blank *A*, with two prongs *e e*, to be closed by the blacksmith upon the steel bit which is inserted between them while the parts are at a welding heat.

Fig. 479.



Axe-Helve Fastening.

The axe is usually fastened to its helve by wedging the latter tightly in the eye, splitting the end of the helve for that purpose.

The eye is peculiarly shaped in Fig. 479, one edge being rounded, and the helve of corresponding shape is driven upon it by a wedge at the back.

In Fig. 480 the helve has a metallic strap secured on the end, and this fits between wedges in the eye. A bolt passes through a cap-piece, and extends through the strap and into the helves. A wrench tightens the bolt.

Fig. 481 shows a metallic cap for the hand-hold

Fig. 480.

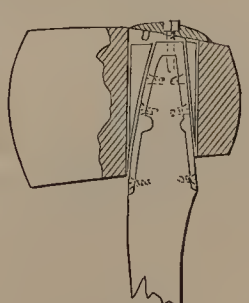
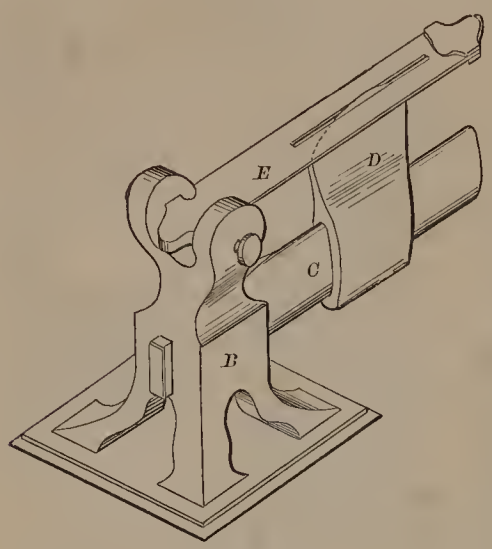


Fig. 481.

of axes. It is secured by a dowel-pin, which penetrates the helve, and a tenon on the latter, which enters a socket in the cap and is wedged therein.

Fig. 482 shows an axe-testing machine. The axe to be tested is slipped upon the bar *C*, towards the

Fig. 482.



Axe-Tester.

standard *B*, until it fits tightly. The gage-plate *E* is then allowed to descend upon the edge of the axe *D*, when, by placing the eye over the slot, the slightest variation from truth may be detected.

Ax'is. A mathematical term. See AXLE.

Ax'le. 1. (*Machinery.*) A shaft or rod on which a pulley, drum, or wheel is placed.

Axles in machinery are known as *Live* axles when communicating power; as *Dead* or *Blind* axles when running, but ineffective, temporarily or otherwise.

Hollow axles are tubular, as their name indicates. They become *sleeve*-axles when the tube is occupied by a rod or tube forming a *live* or *dead* axle, or a fixed axis, as the case may be.

2. (*Vehicles.*) The transverse bar beneath a vehicle, upon whose ends the wheels are placed.

In the *carriage*-axle the wheels rotate on the axle-spindle, the axle-tree being relatively fixed.

In the *car*-axle the wheels are fast to the axle, which rotates therewith. The axle has bearings in boxes. See CAR-AXLE.

Carriage and wagon axles are made tubular for strength and lightness; tubular axles are made from welded iron pipes, such as are used for water and gas. The ends are drawn to a taper for the spindles, a butting-ring is then welded on, and the end fitted with a plug on which a thread is cut for the nut. Hollow axles are also made by taking two swaged hollow portions and welding them together. See patents of Lewis, 1871, 1872.

A *divided* axle is one which is bisected at its midlength; the parts being coupled or otherwise, as the case may be.

The claims to antiquity of this highly useful portion of the carriage do not afford much room for enlargement. The cart and the chariot, whatever may be their order of precedence as regards time, afford the earliest specimens. The details of early forms are comprised in the axle-tree, two spindles, and their linch-pins. Skeins, nuts, straps, clips, boxes, bushing, lubricators, and other devices, seem to have been reserved for the moderns. Axles are made of wood or metal; in the former case the spindles for the wheels are strengthened and preserved by metal (see SKEINS), and the axle-tree itself receives straps and bands, secured by clips and bolts, for the same purpose. Pliny, A. D. 79, recommends ash, oak, and elm for the manufacture of axle-trees. See CARRIAGE, CHARIOT, WAGON.

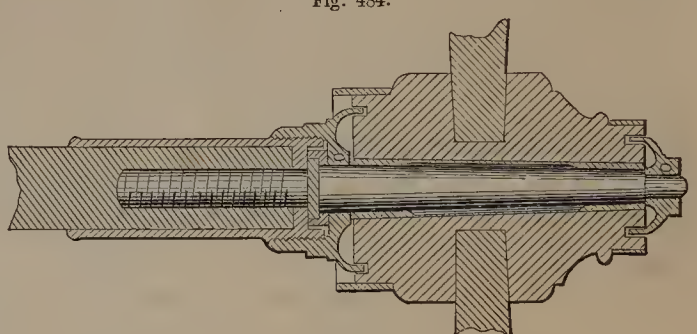
Fig. 483.

Compound Axle.

The arms of the compound truss-axle (Fig. 483) are each made in two parts with an intervening oil-space. One of the parts is placed edgewise, vertically, and the other flatwise, horizontally; the two being united by collars, which form butting-rings, and by screw-nuts, which latter also secure the hubs into the axles.

In Fig. 484 each end of the wooden axle-tree has a cast-metal sleeve, on the outer end of which is a polygonally shaped recess, for a finished metallic spindle, whose shank screws into the end of the axle-tree. A collar on the spindle abuts upon the end of the sleeve and holds it in place. A cap screws on the sleeve, and its flange projects into a face-groove on the inner end of the hub. A similar

Fig. 484.

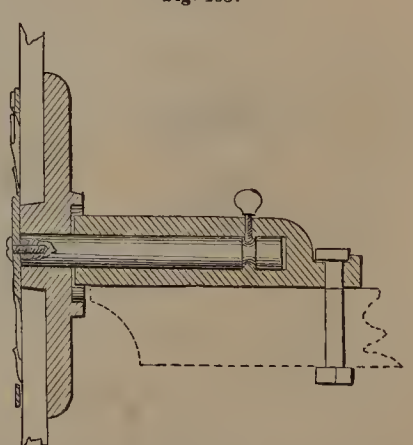


Carriage-Axle.

provision on the outer nut also tends to exclude grit from the bearing surfaces.

While most wheels revolve on the spindles of their axles, others are fast to and rotate with their axles; in the latter case bearings are provided for the axle (as in Fig. 485), in which the parts of the divided axle rotate in bearings attached to the axle-tree. Each portion is received in a long socket-piece, bolted to the axle, and is retained by a set screw, whose inner end passes into an annular groove in the periphery of the axle.

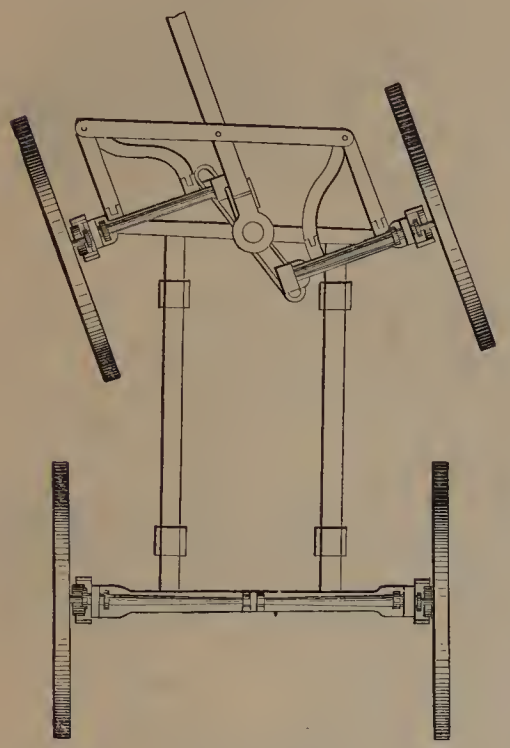
Fig. 485.



Divided Axle.

In one form of divided axle the tongue is pivoted to the front sill-piece of the wagon-frame, coincidently with the pivot of the slotted middle section

Fig. 486.

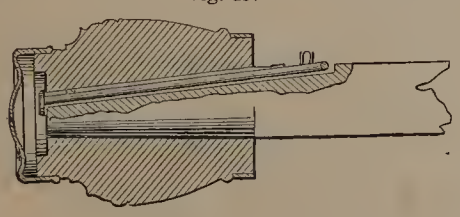


Drew's Carriage-Axle.

of the axle-tree, and the tongue is not affected by the contact of the front wheels with obstructions in the road. The middle section of the axle-tree forms a link in which slip the inner ends of the two outer sections, in which the axles of the wheels have their bearings. Each wheel is secured to its portion of the axle, and each section of the axle-tree is secured by hounds to its respective end of an equalizing bar, which oscillates on the tongue as the wheels swerve out of their course or change their parallelism with the hind wheels. The tongue-hounds are hinged to their sections of the axle-tree, so as to allow the required vertical motion to the tongue, which has also a hingeing joint.

Fig. 487 shows a means of securing the wheel to the axle. It is intended for children's carriages, and

Fig. 487



Denison's Carriage-Axle.

the fastening is not exposed at the outer end of the hub. A rod is fitted in the spindle of the axle, and provided at its outer end with a button eccentrically attached. The button in certain positions bears upon the outer end of the hub, and the inner end of the rod is secured by a staple and key.

The bent or crank axle is much used in city drays, its purpose being to lower the bed without reducing the size of the wheels. Bringing the floor of the vehicle nearer to the ground obviates lifting the load to any great extent. The bent axle, to enable the bed of the cart or wagon to come near to the ground, while retaining a large wheel, is a common device in England in city and rural vehicles. One form of driving wheel-axles for locomotives is also bent. Baddeley, a contributor to the early volumes of the Mechanic's Magazine, London, advocated their use, and may have been the inventor.

Paterson (England) proposed that carriages should have axles of unequal length, so as to avoid "tracking," and thus prevent the formation of ruts.

A *turning*-axle is the fore-axle of a carriage, which turns on the fifth wheel.

A *leading*-axle is an axle of a locomotive, in front of the driving axle or axles. The term is applied especially to the English engines, which are not supported in front by a four-wheeled truck, as with us.

A *trailing*-axle is the last axle of the locomotive. In English engines it is under the foot-plate.

A *crank*-axle is a driving-axle connected to the piston-rods of a locomotive whose cylinders are *inside*, technically speaking.

A *driving-wheel* axle, or *driving*-axle, is the one on which the driving-wheels are keyed. The power is either applied to cranks on the axle, or to wrists on the driving-wheels themselves.

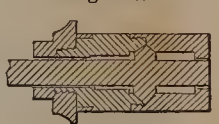
Ax'le-ad-just'er. A machine for *trueing* an axle by straightening out the bends; or one for *setting* the spindle in proper line relatively to the axle-tree. See AXLE-SETTING MACHINE.

Ax'le-arm. The spindle on the end of an axle, on which the box of the wheel slips.

Ax'le-bar. An axle-tree with an arm at each end for a wheel.

Ax'le-box. Carriage axle-boxes are bushings for hubs. Their duty is to take the wear incident to revolving on the spindle of the axle. Some of them are so arranged as to unite the wheel to the axle without the intervention of linch-pins or axle-nuts. Others have rollers to diminish the frictional bearing of the spindle in the box. Others have devices for taking up lost motion. Other devices refer to modes of casting, securing in the hubs, renewing the bearing surfaces, providing thimbles and sleeves of soft metal, which prevent the contact throughout of the spindle and its bearing.

Fig. 488.

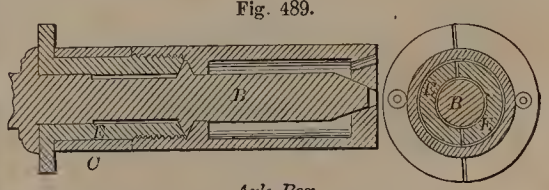


Axle-Box.

In Fig. 488 the spindle has a permanent conical collar, and the box is formed in two portions, which screw together; a groove at the point of junction forming a seat for the collar on the spindle, and holding the latter in the hub of the wheel. The collar is intended to be the only bearing portion, the hole through the box surrounding the other parts of the spindle being made large enough to enable it to revolve without touching.

Somewhat similar is Fig. 489, in which the conical collar on the spindle *B* is used for the same purpose. The inner portion of the box, however, is formed of

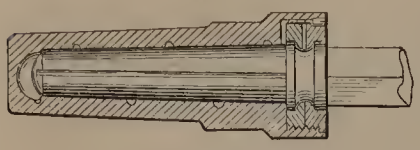
Fig. 489.



Axle-Box.

two semi-cylindrical pieces *E E*, which are held in place, on their portion of the spindle, by a cylindrical band *C*, which slips over them when the parts are in position. The segments have threads cut upon them, upon which the outer portion of the hub is screwed. The tapered end of the spindle *B* abuts

Fig. 490.



Axle-Spindle.

against a conical seat in the outer end of the box. A hole at this end admits oil, and is then plugged.

In Fig. 490 the spindle of the axle has a grooved collar, which occupies the position of the usual butting-ring. The open end of the boxing has an internal thread screwing upon the divided nut, which clasps the collar on the spindle. The box and nut are keyed together by a screw, so as to run together; the nut clasping the permanent collar, so as to keep the wheel on the spindle.

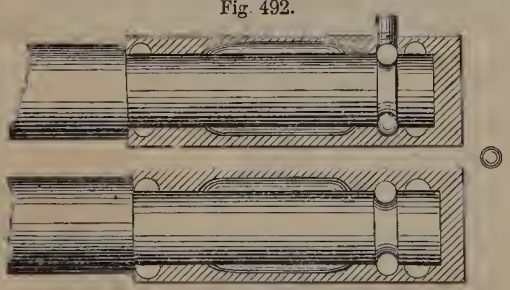
Fig. 491.

Axle-Box.

The axle-box shown in Fig. 491 is cast solid throughout, and is closed in front by a cap. Linch-pins are attached to the axle, and have projections which enter an interior annular groove of the box, so as to keep the latter on the axle. The oil-hole at the end of the box is closed by a screw-plug after oil is applied.

The axle (Fig. 492) has corresponding annular grooves in the adjacent faces of the axle-spindle and the box. A hole in the hub permits a ball

Fig. 492.

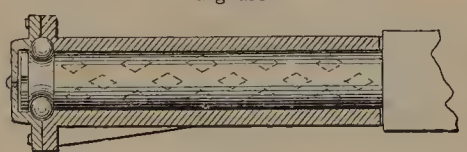


Axle-Box

to be dropped into this groove, and the hole is then plugged. The ball opposes the withdrawal of the box from the spindle. One view is a vertical, and the other a horizontal, longitudinal section.

Fig. 493 has chilled cast-iron balls, which are the means of uniting the box to the spindle; the

Fig. 493.

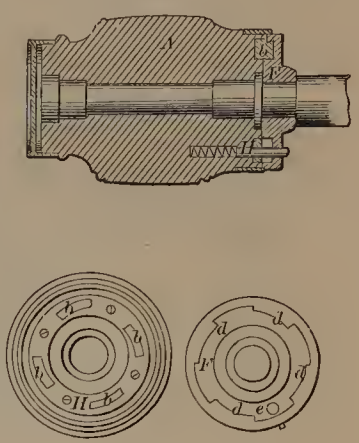


Axle-Box.

balls protruding into grooves in the respective parts. The flange on the end of the spindle has a notch to facilitate the introduction of the balls into the groove of the spindle. The outer groove is formed at the junction of the cap and the box, which are secured together by bolts.

Fig. 494 shows another form in which a collar is turned on the inner end of the spindle, and inside the collar is a groove occupied by an annular cap-piece *F*. The cap *F* is to be attached to the inner end of the hub *A*, to hold it on the spindle of the axle. The lips *d*, on the inner face of the cap, enter between the projections *b* on the face of the hub. The cap is then partially rotated, locking the two portions together; the engagement being maintained by a spring pin *H* in the hub, which enters a perforation in the cap *F*. To detach the wheel, the spring pin is retracted and the cap loosened, permitting the wheel to be removed from the spindle.

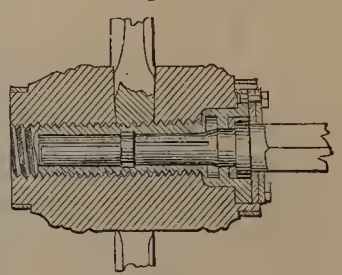
Fig. 494.



Axle-Collar, etc.

The box in Fig. 495 has an exterior thread by which it is screwed firmly into the hub. The ends of the spokes rest upon the thread. The box is widened at its inner end, so as to enclose the butting ring upon the axle, and the flange of the box is bolted to an annular plate on the inside of the butting-ring, so as to hold the box to the axle, thereby securing the wheel in place without any attaching devices on the outer end, such as linch-pin or axle-nut.

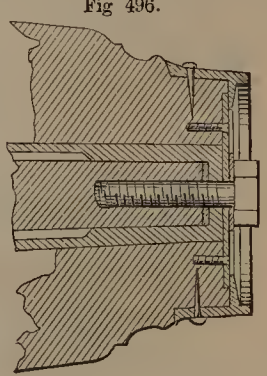
Fig 495.



Axle-Box.

An axial bolt in Fig. 496 screws into the end of the spindle, and its head rests against an annular washer, which is of sufficient diameter to abut against the end of the box and the hub also. The bearing of the attachment is thus upon the outer end of the spindle, the usual butting-ring on the axle is superseded, and the back of the hub removed from any contact with sustaining devices when the wheel vibrates longitudinally on its spindle.

Fig 496.



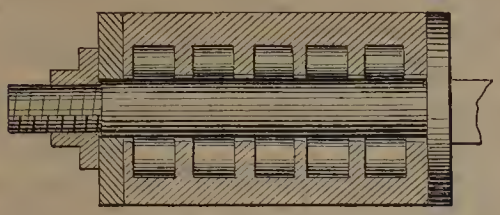
White's Axle-Box.

In the axle (Fig. 497), friction-rollers revolve in the annular chambers of the box, and lessen the friction of the spindle; the latter has a rolling contact, instead of a frictional one.

The planetary system of rollers is a very common device, and a great favorite among inventors. It is applied to bearings of all kinds.

The box (Fig. 498) is in two portions, which form conical or beveled bearings of unequal inclinations at each end of the hub; their inclinations being in

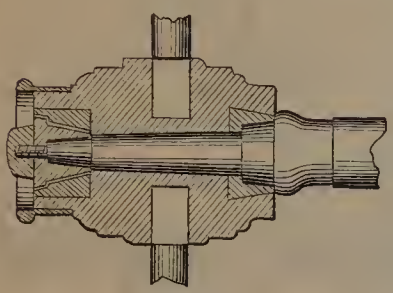
Fig. 497.



Antifriction-Roller Box.

reversed or opposing directions, and the outer having the greater inclination of the two. The attachment is by a nut on the end of the spindle.

Fig. 498.

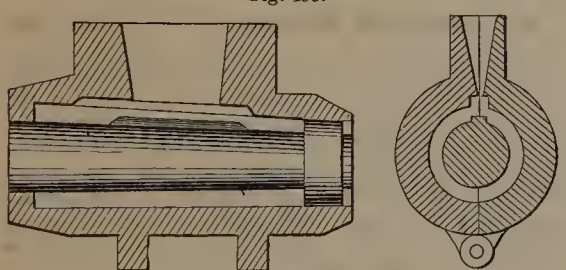


Axle-Box.

Fig. 499 shows a mode of casting axle-boxes in a two-part, hinged, metallic flask, the portion of the gate below the sprue forming the fin of the box. The box is cast upon a chill with a sand core for the oil-chamber.

Upon the butt-end of the box (Fig. 500) is an annular flange with a concave recess formed on its

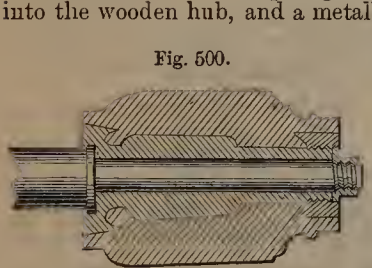
Fig. 499.



Mode of casting Axle-Boxes.

inner surface ; the sharp edge of the flange sinks into the wooden hub, and a metallic nut with a corresponding sharp flange is similarly sunk into the other end of the hub. The object is a firm attachment of the box in the hub.

Fig. 500.



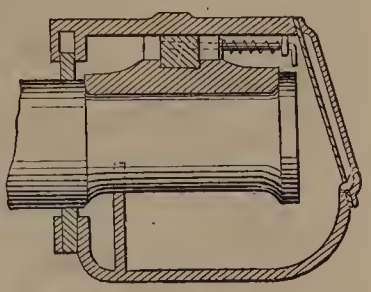
Axle-Box.

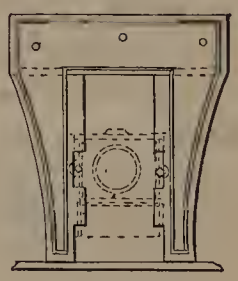
A bearing surface, completely enveloping the spindle, is either a bushing for the box, or is allied to a thimble-skein. This skein may be a cast-iron thimble, a wrapping of wire, a bearing of Babbitt-metal, or an infolding plate of sheet-metal. See AXLE-SKEIN.

Axle-boxes of railway-cars are differently constructed, as may be seen by the example annexed. They consist mainly of a box, bearing, packing, oil-chamber, and removable cover.

Arrangements are made to facilitate the removal of the bearing from the journal of the axle, for the inspection of the journal, or the renewal of the bearing, while the oil-box remains in its place ; also to so combine the oil-box with the axle and jaw, that the oil-box may be easily removed therefrom, for the purpose of renewing the packing in the rear end, etc. See CAR AXLE-BOX.

Fig. 501.





Car Axle-Box.

Ax'le, Car. The bar connecting the opposite wheels of a pair, adapted to support a railway-carriage, or rail-road-truck. The wheels are fast to the axle, and the latter runs in bearings in *axle-boxes*. In this respect the car-axle differs essentially from the carriage-axle, which is relatively fixed, the wheels running upon *it*. See CAR-AXLE.

Ax'le-clip. (*Vehicles.*) A clevis or bow which unites some other part to the axle ; as the *clip* of the thill coupling. The axle-cap or strip, and the ends of the perch-braces, are fastened by clips to the axles.

Ax'le-clip Tie. The cross-bar which unites and fastens the ends of the bow-clip by which a carriage-axle is clasped.

Fig. 502.

Stratton's Axle-Gage.

Ax'le-gage. A tool by which the spindle is so adjusted in relation to the axle-tree, as to give the required *swing* and *gather*.

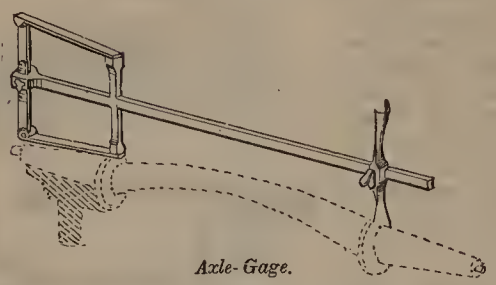
The *swing* is adjusted to give the downward inclination, and the axle is bent to conform to this guide. The *gather* is given by the adjustable standard.

The *swing* is the outward inclination of the top of the wheel, and is to meet the requirements of the conical axle, so that the bottom edge of the spindle shall ride about horizontal. Were the spindle destitute of *swing*, the wheel would ride outward, bearing heavily against the linch pin or nut.

The *gather* is the forward inclination of the spindle relatively to the general line of direction of the axle-tree. It is to bring the forward edge of the taper spindle into a direction nearly transversely across the vehicle, so as to prevent the riding out of the wheel against the hub, which would result from placing a wheel on a conical spindle without *gather*.

Fig. 503 shows a somewhat different form of the gage, in which the concave end of the sliding gage is placed on one spindle, and the other spindle set by the adjustable bars.

Fig. 503.



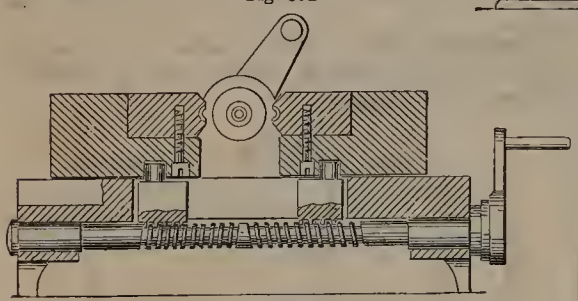
Axle-Gage.

Ax'le-guard. One of the pedestals in which the boxes of an axle play vertically as the springs yield and recoil. Also called *horn-plates, jaws, housings, pedestals.*

Ax'le-hook. (*Road Wagons.*) A hook in front of the axle for the attachment of the stay-chain which connects the axle and the double-tree.

Ax'le-lathe. A lathe adapted to turn axles, shafting, and other relatively long articles which are liable to be swayed or bent by their flexibility or by the pressure of the cutter. Bearings are provided at points between the lathe centers, and sometimes the cutters are duplicated so as to act upon opposite sides simultaneously, as in Fig. 504.

Fig. 504.



Axle-Lathe.

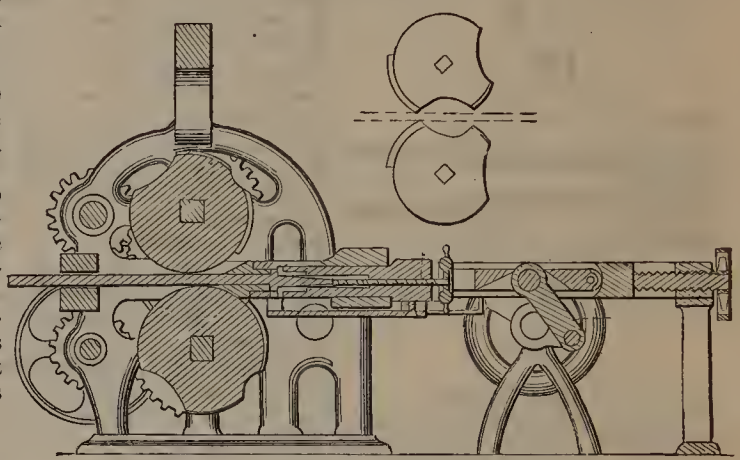
The axle or shafting is turned to form by suitably shaped cutters secured to two jaws, which approach each other by the rotation of a right and left hand screw in a fixed rest.

Whitworth's famous lathe is of this character. See DUPLEX LATHE; CAR-AXLE LATHE.

Ax'le Lu'-bri-ca-tor. A device for containing a supply of oil and supplying it to the spindle inside the axle-box.

There are many forms of this, some having reservoirs of oil in the spindle, others in the box, others outside. In some the lubricant is led to the wearing surface by gravity, in others by cotton wick, in others by a moving cup. See CARRIAGE-WHEEL LUBRICATOR.

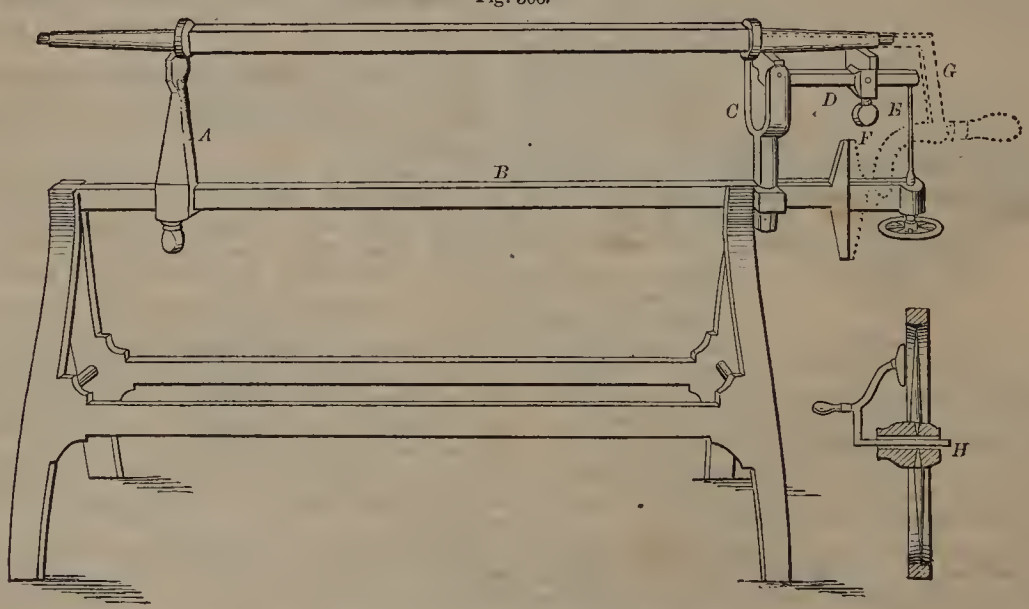
Fig. 505.



Foster's Machine for making Carriage-Axles.

Ax'le-mak'ing Ma-chine'. In FOSTER'S *Machine for making Carriage-Axles,* a bar of metal is fed into the machine and automatically formed into axles, which are cut off as finished. Shaping rollers form the journal and taper the bar of the axle, and dies form the collar by lengthwise pressure of the bar. The rolls act simultaneously upon opposite sides of the bar, and have dies which act coincidently to shape, and sharp edges to cut off at the given length. A pair of rolls are arranged to act perpendicularly to the die-rolls and in concert therewith.

Fig. 506.



Gorton's Axle-setting Machine.

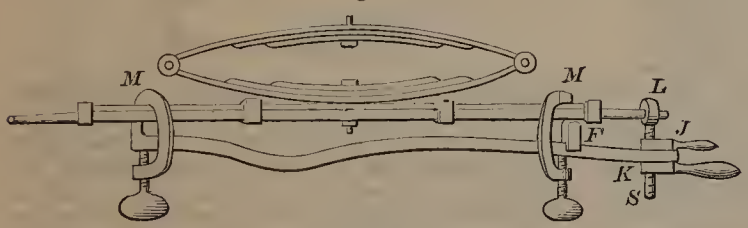
Ax'le-nut. A screw nut on the end of an axle-spindle, to keep the wheel in place. See NUT.

Ax'le-pin. A linch-pin, a fore-lock; a little bar passing through a mortise near the end of the *arm*, to hold the wheel thereon.

Ax'le-set'ting Ma-chine'. The *Axle-setting Machine* (Fig. 506) is for setting the spindles true on the ends of the axle-trees, giving them the required *set* and *gather*.

The uprights *A C* on the frame *B* are adjustable by set screws to any distance. The upright *C* has a jointed bar *D* projecting from it, which rests on a screw-rod *E*. This bar is a straight edge, to show the taper of the axle; for when the same is placed on the uprights, as shown in the engraving, and the stop *F* brought up to it by the screw, the taper will be given by the gage *G*, shown in dotted lines. If the axle does not touch the stop *F*, it is too high on the end, and must be brought down by the blacksmith. If it touches at the end and not at the shoulder, it is too low, and must be treated accordingly. The axle is then turned end for end, and the operation is repeated. The T-end on the frame is to set the T-foot of the gage against, as shown. The angle of the gage is obtained by setting the gage-foot against the spoke, and putting the straight edge *H* in the axle-box, as in the smaller figure.

Fig. 507.



Axle-Adjuster.

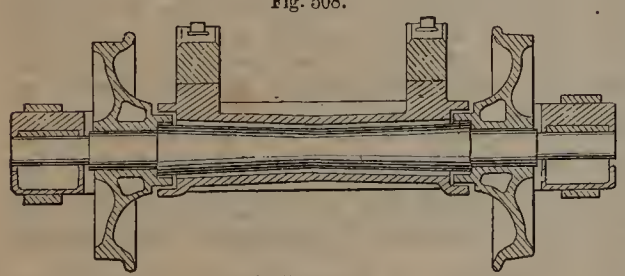
A more portable form of the same general character is shown in the *Axle-Adjuster* (Fig. 507). It consists of a bar hooked on to the axle-tree in two places.

The bar is fastened by clamp *M* and fulcrum-block *F*. The eye-bolt *L* is hooked over the end of the spindle, and the adjustment of the latter is accomplished by the screw *S* and set nuts *J K*.

Ax'le-skein. A band, strip, or thimble of metal on the wooden *arm* or *spindle* of a carriage-axle to take the wear from the wood.

Ax'le-sleeve. One placed around a railway-

Fig. 508.



Axle-Sleeve.

car axle in order to hold up the broken ends if the axle should be fractured.

Axle, Tel-e-scop'ic. An extension axle to allow the running wheels of a carriage to be slipped in or out to adapt them to varying gages of tracks.

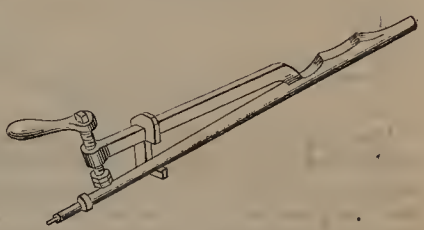
Ax'le-tree. The axle, or transverse bar, on whose ends the wheels of a vehicle are secured.

The term "tree" indicates that it was originally of wood, and is applied as a suffix to many words, such as *Bridge-Tree, Single-Tree, Double-Tree, Boot-Tree, Chess-Tree, Saddle-Tree*, etc. See AXLE.

Jones's axle-trees (*English Patent*) are made of wrought-iron, with pieces of steel welded beneath them near the ends so as to form the spindles. In hardening, the work is heated by a forge fire, a quantity of prussiate of potash mixed with carbonate of ammonia is dusted upon the metal, which is then plunged into the cooling tank, water being allowed to run upon it from a cistern. The prussiate of potash case-hardens the iron. The wheels are on the wrought-iron suspension-principle, having chilled-iron hubs.

Ax'le-tree Clamp. A tool for giving the proper pitch to a new axle-spindle, or for straightening one which is bent.

Fig. 509.



Axle-Tree Clamp.

Ax'minster Car'pet. A carpet with a flax or jute chain and a woolen or worsted filling which is formed into a pile.

The patent Axminster carpet, as made at Glasgow, is made first as a woven fringe, which is afterwards adapted to a thick flax backing.

The carpet is named from the town of Axminster, Devonshire, England, where the manufacture was formerly carried on. It has been discontinued at that place. It is of the Turkey variety. The linen chain or warp is placed perpendicularly between two rolls or beams, one of which carries the warp, and the other the finished carpet. Small tufts or bunches of different colored worsted or woolen are tied to or fastened under the warp; and when one row of these tufts has been completed, a linen weft thread is thrown in and firmly rammed down. Another row of tufts is then knotted in, the selection of colors being such as to carry on the pattern. To guide the weaver as to the position of the colors, a paper design constantly hangs before him. The linen chain and weft are entirely concealed.

Ayr Stone. A Scotch stone, called "Water of Ayr," used as a whetstone and in surfacing metals previous to polishing.

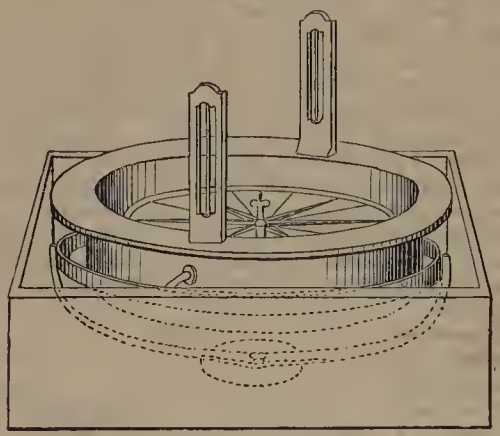
Az'i-muth Cir'cle. The azimuth circle, as an astronomical instrument, is used for determining the azimuths of stars. The azimuth is an arc of the horizon intercepted between the meridian of the place of the observation and the vertical circle passing through the object.

Az'i-muth Com'pass. This compass is graduated in degrees instead of being divided by *rhumbs*, like the *Mariner's Compass*. It has sights to allow the angles to be taken more accurately, and is designed to show the bearing of objects in respect to the magnetic meridian.

By a comparison of the magnetic azimuth of a heavenly body with the true azimuth as found by calculation, the variation of the needle is determined.

The instrument is shown in the accompanying figure. The sight-plates ascend perpendicularly, and their slits are bisected by a perpendicular thread or wire, serving as sights.

Fig. 510.



Azimuth Compass.

The ring of the gimbals rests with its pivots on the semicircle beneath, the foot of which turns in a socket; so that, while the box remains steady, the compass may be turned around so as to bring the sights into coincidence with the sun or other object observed.

The pivots of the gimbals, in this as in steering-compasses, should lie in the same plane as the point of suspension of the needle, so as to diminish the irregular vibration as much as possible.

In the inside of the compass-box lines are drawn perpendicularly down from the points where the sight-threads meet the sides of the box. These indicate the number of degrees, and parts of a degree, which the object bears from the magnetic north or south, on which account the middle of the apertures of the sight-vanes, the threads, and the above-mentioned lines should be exactly in the same vertical plane at the time of reading off the observation.

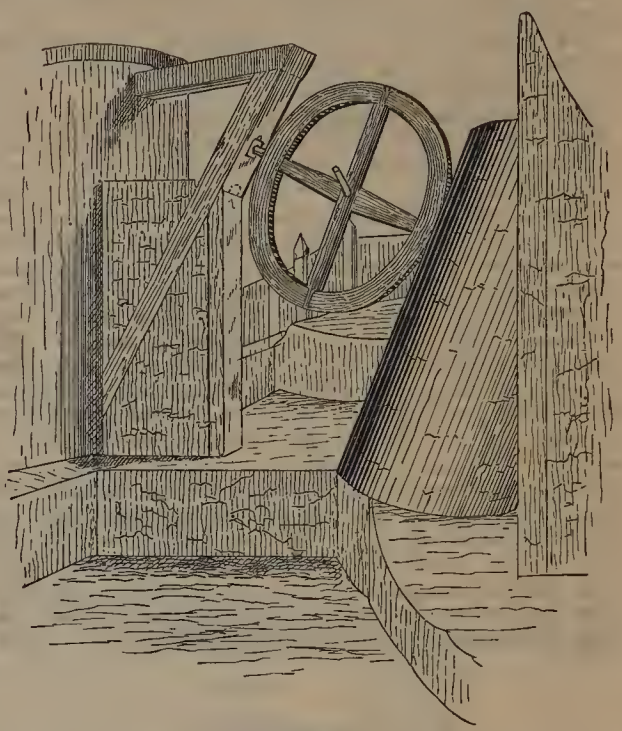
On one side of the compass-box is usually a nut or stop, which, when pushed in, arrests the vibratory motion of the card while the observer is noting the reading.

Az'i-muth Cir'cle. The cut (Fig. 511) illustrates an equatorial dial, according to Dr. Hooker probably a *Kranti-urit*, or azimuth circle, in the observatory at Benares, built by Jey-Sing, Rajah of Jayanagar, upwards of 200 years ago.

Dr. Hooker describes the astronomer-royal at the time of his visit as a "pitiful object," half naked, with a large sore on his stomach, who represented himself as being very hungry. Science, it would seem, has not been properly appreciated in that vicinity since the decline of the Mohammedan power. See Dr. Hooker's Himalayan Journals, London, 1855.

The equinoctial and equatorial sun-dials of Benares are considered under DIAL, where it will be seen that the former has a gnomon 30 feet long, and is ascended by steps; each quadrant is nine feet long. The fact of the ascent by steps throws interesting light upon the passage in the Second Book of Kings, chap. xx., where the "dial of Ahaz" (742 B. C.) is referred to. White says that the Hebrew word signifies a staircase, and in this form doubtless were the dials of the Mesopotamian nations, and that seen at Damascus by Ahaz, and afterwards copied by him in the one set up in Jerusalem. See ASTRONOMICAL INSTRUMENTS, where the large dial of Benares, referred to by Dr. Hooker, is shown on the elevated terrace on the left. Very remarkable and interesting are these relics which carry us back to the old times when, and the old means whereby, the astronomers of Chaldea and Egypt observed the heavens. When we consider their great discoveries, and recollect that they were destitute of lenses, as well as of means for minute and accurate graduation of instruments, we may well hold them in high respect. See ARMIL; ARMILLARY SPHERE.

Fig. 511.



Brass Azimuth. Benares.

The sun-dial of Delhi was also used as an observatory, and is described by White, of the East Indian Military Staff, as "a large circular building, having a number of openings or windows in the walls, and a pillar or gnomon in its center. Each of these windows had an appropriate astronomical term, and at night the position of the heavenly bodies was defined by the window or house in which it might be seen by a person stationed at the pillar; and during the day the time was regulated from the particular window through which the sun shone on the gnomon." The gnomon cast a shadow on the circular wall, which was graduated for that purpose. See DIAL.

The *gnomon* erected by the astronomer Uleg Beg, in 1437, at Samarcand, had a hight of 175.89 feet.

Az'i-muth Di'al. An azimuth dial is so called because the shadow marks the sun's azimuth. The stile, or gnomon, is perpendicular to the plane of the horizon.

Azogue. A Spanish ship fitted for carrying quicksilver.

B.

Bab'bitt-met'al. An alloy, consisting of 9 parts of tin and 1 of copper, used for journal-boxes; so called from its inventor, Isaac Babbitt, of Boston (patent, 1839). Some variations have been made, and among the published recipes are

Copper	1	1
Regulus of antimony	1	5
Tin	10	50

Another recipe substitutes zinc for antimony.

The term is commonly applied to any white alloy for bearings, as distinguished from the *box-metal* or *brasses* in which copper predominates.

Bab'bitt-ing-jig. (*Machinery.*) A tool used in babbitting the shafts and journals of machines. It holds the parts — of a harvester, for instance — in their respective positions, and also in proper relation to their boxings, so that the anti-friction metal may be run around each of the journals in succession.

Ba'by-jump'er. A cradle, basket, or sling in which a child is suspended. The suspensory cord is usually adjustable as to length, and, being elastic, permits a saltatory motion.

Ba'by-walk'er. A go-cart. A frame traveling on casters, and used to support an infant while learning to walk.

Bac. 1. (*Nautical.*) A broad, flat-bottomed ferry-boat, adapted for conveying horses and carriages, and usually navigated by a rope fastened on each side of the stream.

2. (*Brewing.*) A cistern with a perforated metallic bottom, used for straining the hops from the beer previous to its entrance into the cooler. Also written *back.*

Back. The part of an object against which the back of a person leans, as of a chair, carriage, etc.

The rear portion of an object.

The upper part of a thing, as of an arch, hand-rail, saw, etc.

1. (*Forging.*) A cast-iron plate forming the back-wall of a forge, and through which the blast enters by a *tuyere.*

When the back consists of an iron cistern, it is called a *water-back.*

When it consists of a chamber in which the air-blast is heated, it is a *heating-back.*

2. (*Bookbinding.*) The part to which the sides of the cover are attached, and which receives the lettering.

3. (*Architecture.*) *a.* The rear surface of a wall.

b. The rear wall of a fireplace.

c. The extrados of an arch or vault.

d. The rear part of a stone or ashlar, parallel with the *face* or exposed surface.

4. (*Cork-cutting.*) The burnt side of a slab of cork.

5. (*Brewing, etc.*) A vat or cistern.

a. Water-back: a supply cistern in a brewery, etc., containing water for mashing.

b. Under-back: a cistern below the *mash-tun,* which receives the *wort* therefrom.

c. Hop-back: a cistern below the copper, which receives the infusion of malt and hops from the latter.

d. Jack-back: the same as *hop-back.*

e. (*Glue-making.*) *Settling-back:* a cistern in which a solution of glue from the kettle is received and kept warm till the impurities have time to settle.

f. (*Distilling.*) *Wash-back:* a cistern or vat in which the *wort* is fermented to form *wash* for distillation.

g. Spirit-back: the cistern which receives the spirit.

In this sense the word is nearly allied to *beck;* as a *dye-beck* or *soap-beck* in a dye-house. See BECK.

6. (*Carpentry.*) *a.* The upper surface of a hand-rail; the under side is the *breast.*

b. The same distinctions apply to the ribs of domes and rafters of roofs.

c. The *back* of a window is the wainscoting below the sash-frame and extending to the floor.

d. The upper edge of a saw as opposed to the edge which is serrated.

7. (*Mining.*) *a.* The part of a lode nearest to the surface.

b. The ground between one level and another is the *back* of a level.

8. (*Shipbuilding.*) *a.* The convex surface of a compass-timber.

b. Figuratively, the keel and keelson of a ship.

c. A timber bolted on behind the sternpost.

9. (*Nautical.*) *a. To back an anchor:* to place a small auxiliary anchor ahead of the one from which the ship rides.

b. To back a sail: to brace a yard so that the wind blows in front of it.

c. To back astern: to give the vessel sternway.

d. To back a rope: to put on a *preventer* to take a part of the strain.

e. To back the worming: to fill the crevices between the strands, to bring the surface flush and even, ready for *serving.*

Back-ac'tion Steam-en'gine. One in which the connecting-rod, pitman, and crank are so arranged as to take up but little longitudinal space. The cross-head on the end of the piston-rod is connected by parallel side-bars to a cross-tail, which, by a backwardly reaching pitman, is connected to the crank of the propeller engine. One of the side-bars passes above the crank, and the other below it. Being used for propeller engines, the crank and shaft must be amidships and the engine and appurtenances lie upon the floor athwart-ship. "Juniata" and ten sister vessels of the United States navy are of this class.

Back-bal'ance of Ec-cen'tric. (*Steam.*) The weight fixed to the back of an eccentric-pulley for the purpose of balancing the weight of the pulley on the shaft.

Back-bal'ance of Slide-valve. (*Steam.*) The weight fixed at the extremity of the valve-lever for balancing the weight of the slides.

Back-band. (*Saddlery.*) The band or strap which passes over the back of the horse and meets the belly-band; the two unite to girth the horse.

Back-cen'ter. (*Turning.*) The point on the *back* or *dead spindle* of a lathe which supports that end of the work. The front-center is on the *live-spindle* in the head-stock. It is set up by the *back-center screw.* See LATHE.

Back-cloth. (*Calico Printing.*) The cloth sustaining the fabric in one form of calico printing.

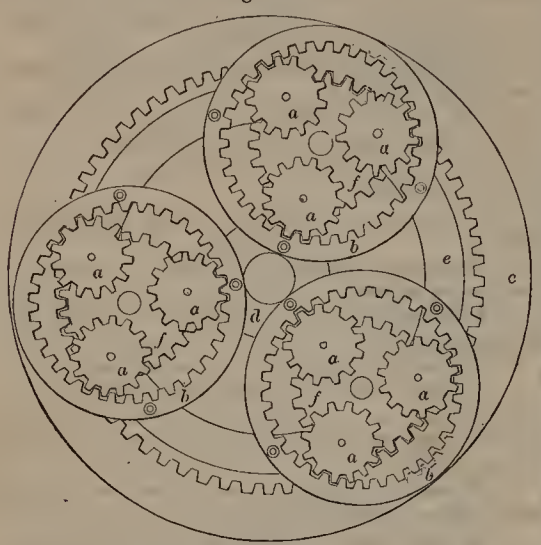
Back-cut'ting. (*Civil Engineering.*) Earth obtained for a canal bank, when the excavated earth does not suffice.

Back'er. (*Slating.*) A narrow slate laid on the back of a broad, square-headed slate, at the spot where a course of slates begins to diminish in width.

Back-flap. (*Joinery.*) The leaf of a window-shutter which folds inside the casing, and is concealed when closed.

Back-frame. (*Rope-making.*) A wheel for turning the *whirlers* of a rope-making machine. The whirlers, to which the ends of the strands are connected, are stocked in the centers of the pinions *a a a*, which roll around inside the internally geared ring *b*, as the frame *c d* rotates. The frame *c d*, with its three annular gears *b b b*, and their respective

Fig. 512.



Back-Frame.

wheels *f a a a*, are revolved so that the wheels *f* mesh with the internal cogs of the annular gear *c*, causing the wheels *a a a* of each system to rotate on their axes, and thereby twist the yarns into strands; to *revolve* around each other, and thereby lay up their three strands into a rope; while, at the same time, the three systems revolve around each other, and lay up the three ropes into a hawser or larger rope.

Back-gam'mon. A game of chance and skill, played by two persons, with fifteen men each upon a board having twelve black and twelve red *points*. It is a Welsh game, and is said to have an antiquity of a thousand years. Rameses and his ladies played checkers. Chess came from India; so did cards.

Backgammon is mentioned by Chaucer, Shakespeare, and Bacon as "playing the tables,"—a name by which it was then known.

Back-gear. (*Turning.*) The set of variable speed gear-wheels in the headstock of a power-lathe.

Back'ing. 1. (*Masonry.*) The coursed masonry next to the extrados of an arch, and resting thereon.

2. (*Fabric.*) The web of coarser or stronger material at the back of such goods as velvet, plush, satin, Brussels carpet, etc.

3. (*Printing.*) Printing the second side of a sheet.

4. (*Type.*) Filling in the back of an electrotype. See BACKING-UP.

5. (*Ship.*) The rear support of an armor-plate. This is of timber, from twice to four times the thickness of the armor, with or without an inner skin, about one eighth the thickness of the armor-plates; sometimes supported by vertical frames.

Compound backing consists of alternate layers of wood and iron, in the usual proportion of 4½ wood to ½ plate-iron. See ARMOR-PLATING.

Back'ing-boards. (*Bookbinding.*) Those between which a *book* is grasped to be laid in the press while the back is rounded. See CUTTING-PRESS.

Back'ing-ham'mer. (*Bookbinding.*) The bookbinder's hammer for rounding the back of a book.

Back'ing-off. (*Spinning.*) The retrograde motion of the mule when it recedes from the creel and draws the yarn from the spools. Its *putting, running-in*, or *going-in*, is the motion towards the creel when the winding takes place on the spindles of the mule. See MULE.

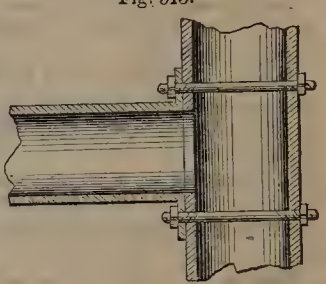
Back'ing-up. 1. (*Engraving.*) Removing a hollow or mark from the face of a plate by blows from the peen of a hammer applied to the back, the face being laid on an anvil or stake. This mode is used by engravers in obliterating lines too deep to be treated by the scraper or burnisher.

2. (*Type.*) The process of fortifying with type-metal the back of the thin electrotype plate which has been deposited on the face of the mold obtained from the *form* of type.

The back of the copper shell receives a thin coating of tin, and is then placed face downward in a shallow iron dish in which it is secured by rods. The dish is then suspended from a crane and swung over a bath of molten metal. When it has acquired the temperature of the bath, a quantity of type-metal is dipped up and poured over the back of the copper plate, forming a solid backing. A planing-machine reduces the backing to an even thickness, bringing the whole to a thickness of say one seventh of an inch.

Back'ing-up Flange. (*Machinery.*) A collar on a pipe by which the latter is held to its bearings or seat.

Fig. 513.



Backing-up Flange.

Back-joint. Such a one as that formed by a rabbet on the inner side of a chimney-jamb to receive a slip.

Back-lash. The reaction or striking back of a piece of machinery, wheel, piston, etc., when the power makes a temporary pause, or a change of motion occurs. It is a consequence of bad fitting or wear, and, in the latter case, indicates that the parts should be *set up*. The gib, cotter, and strap of the pitman connection are an instance of provision for said readjustment.

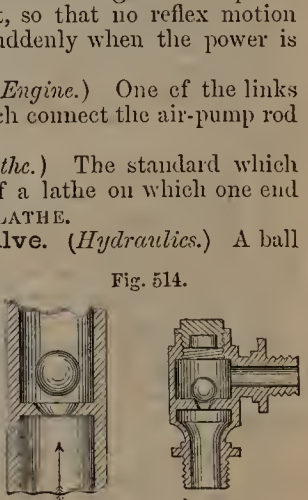
In some cases springs are arranged to keep the parts in positive contact, so that no reflex motion occurs, to be taken up suddenly when the power is again applied.

Back-link. (*Steam-Engine.*) One of the links in a parallel motion which connect the air-pump rod to the beam.

Back-pup'pet. (*Lathe.*) The standard which holds the back-center of a lathe on which one end of the work rests. See LATHE.

Back-pres'sure Valve. (*Hydraulics.*) A ball or clack-valve in a pipe, which instantly assumes its place upon its seat when a reflex or back pressure occurs.

Fig. 514.



Back-Pressure Valve.

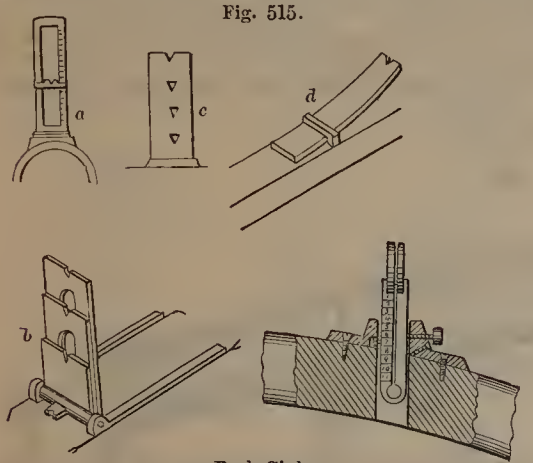
The figure with the arrow shows the normal condition; the other figure shows the valve on its seat.

Back-rope. (*Nautical.*) One of the ropes connecting the lower end of the *dolphin-striker* with the ship's head.

Back-saw. A saw whose web is stiffened by a metallic back of greater substance; as, a tenon saw.

Back-sight. 1. (*Fire-arms.*) The rear sight of a gun. It may be of various forms. In the old-fashioned arms intended for round balls, it was merely a notch in a knob or plate near the breech of the gun, the proper elevation to be given being estimated by the marksman. As the effective range scarcely exceeded 250 to 300 yards, this could be done with sufficient accuracy by an expert marksman; but with the introduction of the elongated bullet, giving ranges of 1,000 yards and upward, it became necessary to seek some more efficient means of securing the proper range at these long distances, so that the bullet might not either pass over or fall short of the object. For this purpose was introduced

Fig. 515.



Back-Sights.

the rear-sight (*a*, Fig. 515), consisting of an upright slotted branch, which was jointed to a seat on the barrel of the gun, or, in some instances, on the small of the stock in rear of the barrel. A notched slider on the upright branch could be elevated as desired, and by elevating the muzzle of the gun until this notch and the front-sight were in line, any range within the limit of projection of the piece could be attained.

This sliding sight has, in the United States service, been superseded by the leaf-sight (*b*, Fig. 515), which is more compact and less liable to derangement. Also called *Folding-Sight.*

Other back-sights, especially those first introduced in Southern Germany, have been made very different in form from those described; one variety (*c*, Fig. 515) being permanently fixed perpendicularly to the barrel, and having notched holes at proper hights through which to sight, and another (*d*, Fig. 515) being segmental in shape, and moving circularly in a direction longitudinal to the barrel through a stud fixed thereon.

Another form of back-sight (*e*, Fig. 515) vertically adjustable for range, and attached to the stock, has a graduated spring-piece slipping within a vertical slot in the small of the stock, and is adjusted as required. Its spring retains it in place, or it may be clamped by a set-screw or lowered below the line of the hind-sight on the barrel.

2. (*Leveling.*) The reading of the leveling-staff; taken back to a station which has been passed. Readings on the forward staff are *fore*-sights.

Back-staff. (*Opties.*) A peculiar sea-quadrant, invented by Captain Davis, 1590. It has a graduated arc of 90° united to a center by two radii, with a second arc of smaller radius, but measuring 6° on the side of it. To the first arc a vane is attached for sight; to the second, one for shade; at the vertex the horizontal vane has a slit in it. The back of the observer is turned towards the sun at the time of observation. (*Admiral Smyth.*)

It is now superseded by instruments of more modern type, such as the reflecting quadrant and sextant.

Back-stay. (*Shipbuilding.*) One of the guy-ropes, just abaft the shrouds, extending from all topmast-heads to the sides of the ship, to stay the masts. They are attached to *back-stay stools*, which are detached channels or chain-wales.

Back-strap. (*Saddlery.*) The strap passing along the back of the horse.

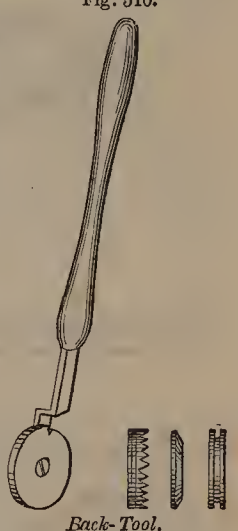
In wagon harness it extends from the upper *hame-strap* to the *crupper;* or, in the absence of a crupper, to a point of junction with the hip-straps.

In carriage harness it extends from the *gig-saddle* to the *crupper.*

Back-sword. A sword with one sharp edge, in contradistinction to one which has two edges throughout the whole or a portion of its length.

Back-tool. (*Bookbinding.*) A fillet, roller, or other hand-tool for dry-tooling or gilding the backs of books.

Fig. 516.



Back-Tool.

Back'wa-ter. (*Hydraulic Engineering.*) Water reserved at high tide for scouring a channel or harbor by discharge at low-tide. See FLUSHING.

Bad'ger Plane. (*Joining.*) A *panel plane* whose mouth is cut on the skew, and from side to side, so as to work up close to a corner in making a *rabbet* or *sinking.*

Ba-dig'eon. A cement for stopping holes and covering defects in work.

Statuary's: plaster and free-stone.

Joiner's: sawdust and glue; whiting and glue; putty.

Cooper's: tallow and chalk.

Stone-mason's: wood-dust and lime slaked together, with stone-powder or sienna for color, and mixed with alum-water to the consistence of paint.

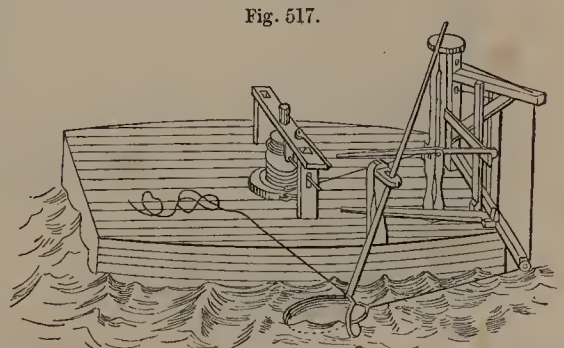
Ba'e-tas. (*Fabric.*) A plain unchecked woolen stuff, manufactured in Spain and Portugal.

Baft, Baft'as, Baf'fe-tas. (*Fabric.*) *a.* A blue or white cotton goods, used in the African trade.

b. A kind of East Indian cotton piece-goods.

Bag and Spoon. (*Hydraulic Engineering.*) An implement used in dredging for river sand.

Fig. 517.



Bag and Spoon.

It is a hoop of iron with a steel lip, and has one edge pierced with holes, for the attachment of a leather bag by lacing. The spoon is suspended by a chain, and has a long handle by which it is guided.

Being sunk in position, it is drawn along the bottom, hoisted by a crane, and dumped into a lighter or mud barge. The bag is perforated for the escape of water. The cut shows the bag overboard, and about to be sunk to the bottom by means of the pole.

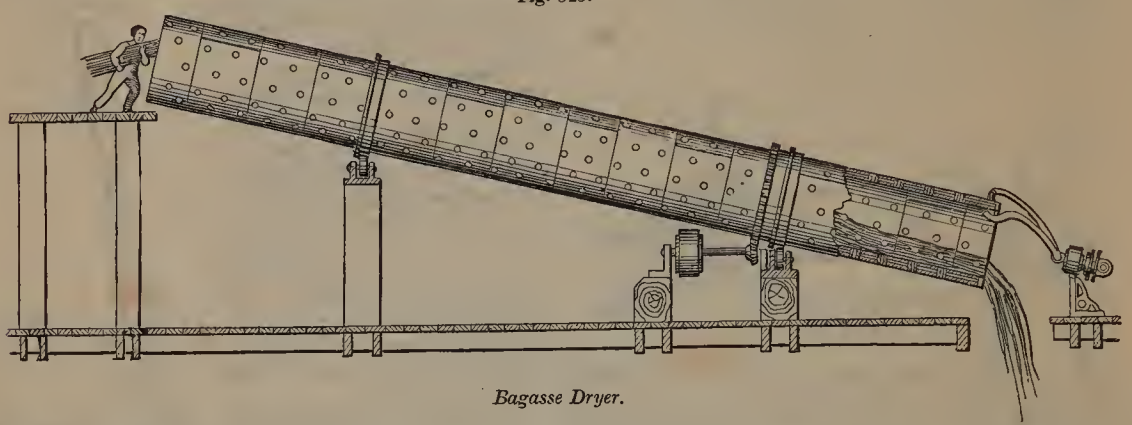
Ba-gasse' Dry'er. Bagasse is crushed cane as it comes from the mill, deprived, to a great extent, of its juice and saccharine matter; also of the leaves, which are stripped from it previous to grinding. According to Wray, good mills only extract from 70 to 75 per cent of the saccharine matter which analysis shows to be present in the cane, and the remainder, after the water is evaporated, joins with the fiber and other carbonaceous matters to form a fuel, coal and wood being very expensive in sugar-cane regions.

The bagasse is sometimes carted to the field, to be dried by the sun, but a number of United States patents have been granted for apparatus for drying it by artificial heat. Other furnaces are constructed merely for burning it to get rid of it. Vast piles of it accumulate round the mill-houses.

In MERRICK'S patent of April 10, 1845, the bagasse is transferred to an inclined chute, whence it is taken by an endless apron, which passes around reels or drums, and conducts it through a series of three heated compartments, finally depositing it on a plate or platform in front of the furnace, or other convenient position.

Another form of the Bagasse Dryer consists of an inclined open-ended cylinder, having a steam jacket and hollow bolts, through which escapes the water evaporated from the cane. The steam is introduced through hollow trunnions, and the dryer-tube is rotated by pinion and annular gear, as shown in the figure. The material is fed in at the upper end, and works gradually to the lower end, where it forms a

Fig. 518.



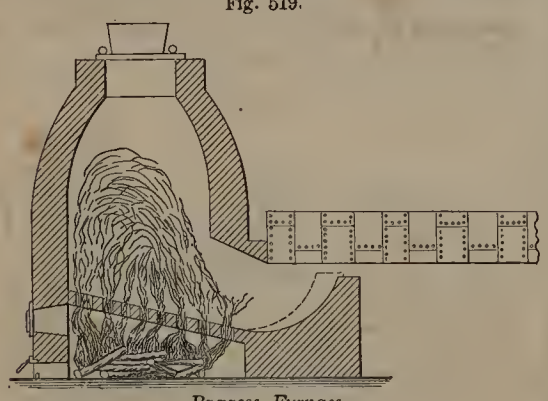
Bagasse Dryer.

pile of dry stuff, and is forked into the furnace beneath the sugar-pans and the engine which runs the establishment.

Ba-gasse' Fur'nace. A furnace for consuming the bagasse (or megass), the cane remaining after the pressure of the saccharine juice therefrom. It generally consists of a kiln or large chamber with a flue to the furnace-space beneath the boilers which make steam for the cane-mill.

The principal reason for burning it is to get rid of it, as it accumulates around the sugar-house and

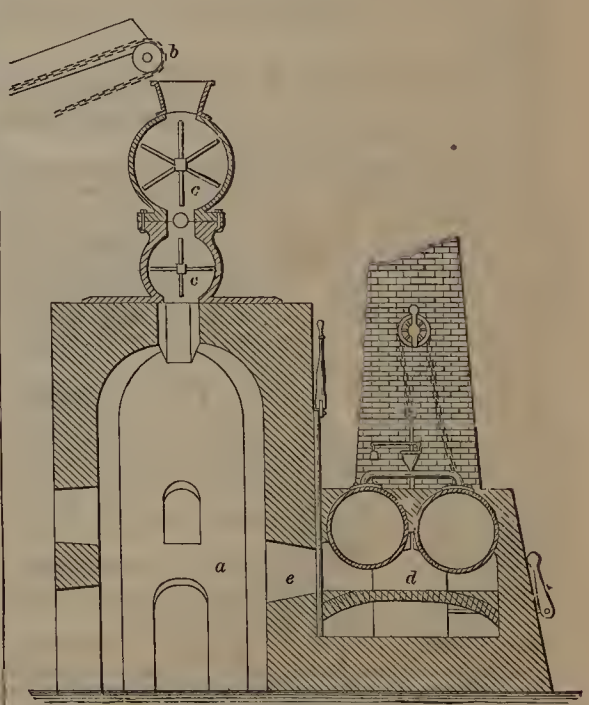
Fig. 519.



Bagasse Furnace.

becomes quite a nuisance. By dint of making a roaring fire, it may be consumed, and perhaps add something more to the fire than it subtracts by the evaporation of its water. The example (Fig. 519) shows it as dumped in a pile upon the grating above the fire. The heat resulting from the combustion of the bagasse and fuel thence passes beneath the boilers which drive the sugar-mill, and, in some sugar-

Fig. 520.



Bagasse Furnace.

houses, heat the vacuum-pans, defecators, surface-evaporators, and run the pumping-engines.

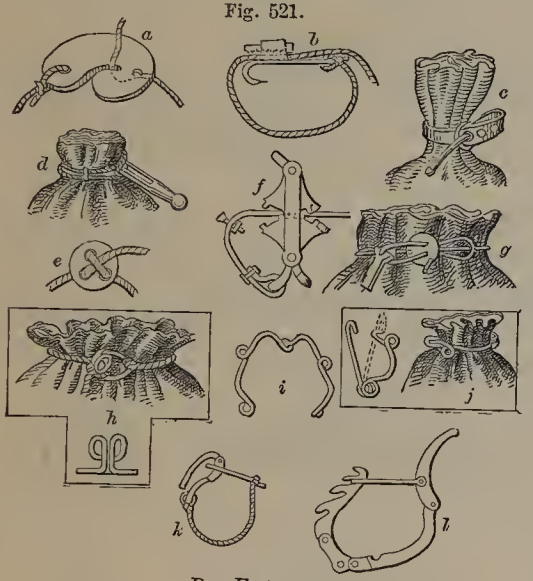
Fig. 520 shows a furnace for burning the cane-refuse, and the relation of the furnace proper *a* to the discharge-apron *b* of the cane-mill, the feeding devices *c c* and the furnace *d*, of the steam-boilers. The bagasse does not pass beneath the boilers, but the flame of the furnace *a* is carried into *b* through the flue *e*, and additional air is admitted beneath the grating of *d* by dampers in the ash-pit.

Bag-clasp. A clamp or cincture for closing the mouths of bags. See BAG-FASTENER.

Bag-fast'en-er. A device for clamping or tying the mouths of bags below the hem. A substitute for a bag-string.

A number of different modes are shown in the illustration, and will be briefly described.

Fig. 521.



Bag-Fasteners.

a. A sheet-metal tag, with a curved tapering slot, is permanently attached to one end of the string. The other end of the string becomes jammed in the slit.

b. The metallic tag attached to one end of the string has a thimble in which the other end of the string is jammed by a wedge.

c. One end of the string has a permanent ring. The other end is rove through an eyelet in itself, and jams against the ring.

d. One loop is permanently attached to a slotted lever. The latter is rove through the other loop and turned over beyond the dead-center, so as to jam the loop against the standing part.

e. The standing end is rove through two holes in the tag, and forms a loop which jams down upon the point end of the cord.

f. The point end is jammed between two pivoted, cogged sectors.

g. The perforated leather tag is riveted to the bag, and the thong is rove through the holes so as to bind tightly.

h. One end of the cord is knotted to the loop of the wire. The other end is passed round the bag and jammed between the jaws.

i. A pair of hinged clasps whose free ends interlock.

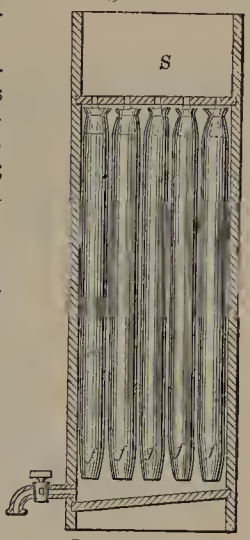
j. A spring device, acting in the manner of a brooch ; a spring pin engaging a catch.

k. A lever attached to one end of the cord engages a loop on the other end, and is thrown over to carry the loop to a curved portion, which holds it securely.

l. Similar to the last, but having a means of adjustment.

Bag-fil'ter. (*Sugar-Refining.*) A device sometimes used in clearing saccharine solutions of feculencies and impuritics mechanically suspended therein.

Fig. 522.



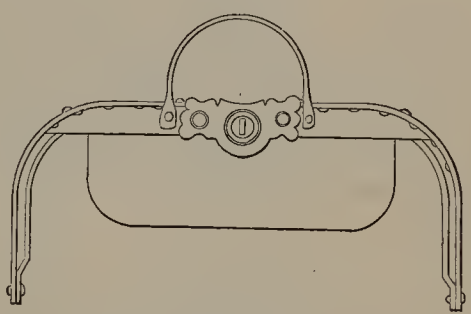
Bag-Filter.

In one form the juice is allowed to pass through a series of copper-wire sieves of gradually increasing fineness before reaching the flannel bag; perhaps the more usual form is that in which the sieves are replaced by the series of vertical flannel strainers arranged in a lower chamber, having a stopcock, into which the juice is admitted from a compartment above.

The example consists of a sirup-cistern *S*, in whose floor are short pipes of conical form, to which flannel bags *f* are tied. The juice, passing down each of the pipes, distends the bags, and drips down their outer surfaces, collecting in the chamber below, whence it is drawn by a faucet.

Bag-frame. The metallic frame to which the leather or cloth part of a carpet-bag or valise is secured, serving to impart stiffness and afford means of attachment for the handle and lock.

Fig. 523.



Bag-Frame.

Bag'gage-check. A tag or label to be attached to a trunk, to indicate its destination; usually, also, its point of departure, and frequently the name of the railway company attaching the said check.

The devices are numerous.

a (Fig. 524) shows a check or label-holder of two metallic portions which form a frame for the inclosed card, on which is inscribed the name of the place of destination. This is nsed also for mail-bags.

b is a lock-up case for a number of such cards, either of which is exposed at the opening as may be required.

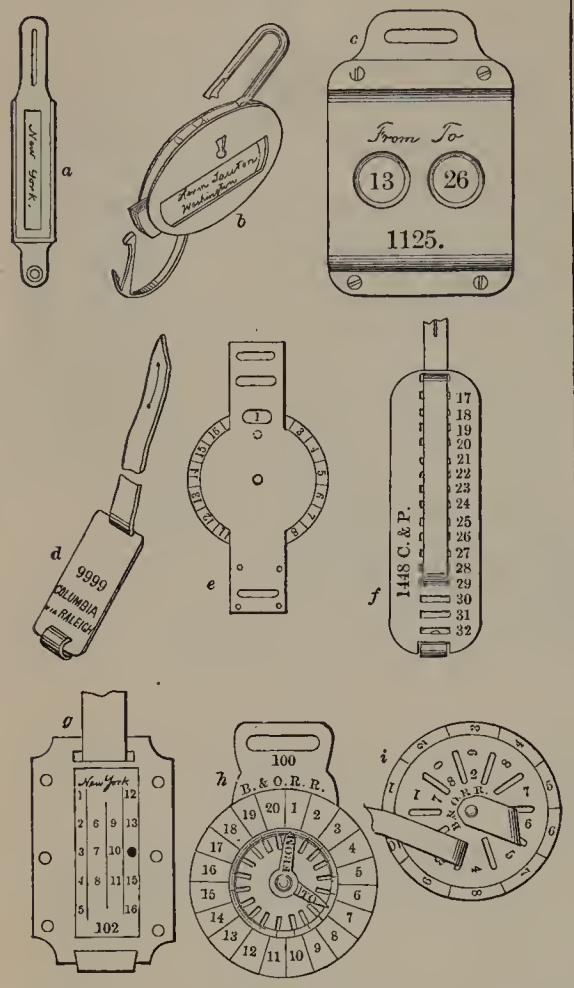
c has two series of numbers on wheels, and the places of departure and destination are indicated by numbers agreeing with the schedule of stations.

d has the places of departure and destination on the respective sides. Either of the readings may be hidden by the strap which is rove through the loop at the other end from that of its attachment to the check. On the return trip, the other side of the check is exposed by the inverse reeving of the strap.

e has a disk with a circumferentially numbered margin. A number agreeing with the schedule-number of the station for which the baggage is bound is exposed at the opening in the plate. By an arrangement of the strap, the latter is made to hold the

disk, so as to secure the required presentation of figure.

Fig. 524.



Baggage-Checks.

f has the series of station-numbers in a row; the strap is so rove through the slots as to indicate the station (29) at which the baggage is to be put off.

g is a metallic case inclosing a card with the numbers of the stations printed thereon. A punch-mark indicates the station of destination (14 in the illustration). The strap holds the parts of the case together, being rove through the loops.

h has a dial-plate and pointers, which indicate the station of departure and destination.

i is a metallic disk with radial slots and corresponding numbers. The strap is so rove through the slots as to give the required indication.

Bag'ga-la. (*Nautical.*) A two-masted Arabian vessel, frequenting the Indian Ocean. A *dhow*. The capacity is from 200 to 250 tons.

Bag'ging. (*Fabric.*) 1. A coarse fabric made of old ropes, hemp, etc., for covering cotton-bales.

2. The gunny-cloth of India is made from jute. In Bengal, from one or two species of *Corchorus;* in Bombay and Madras, from the *Crotalaria juncea.*

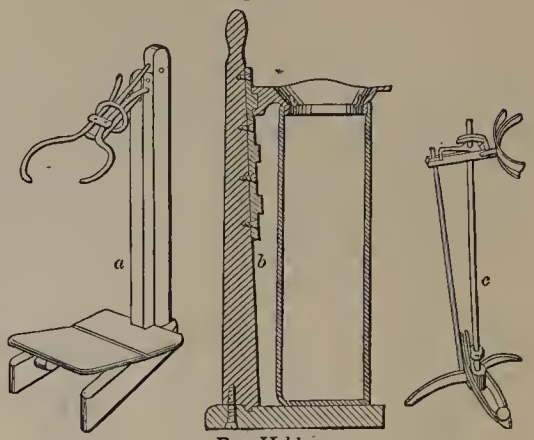
Bag-hold'er. A contrivance to hold up a bag with the mouth open ready for filling. There are many forms, — some adapted for large grain-bags, others of a smaller size for flour, seeds; still smaller, for ordinary groceries and counter use.

a has a platform on which the sack stands, and its weight spreads the horns within and distends the mouth of the sack.

b has a holder adjustable as to hight, and a hopper to which the mouth of the bag is attached.

c has clasping bars operated by a foot-trigger.

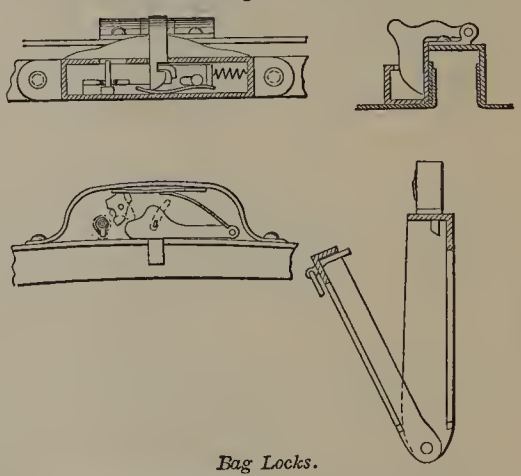
Fig. 525.



Bag-Holder.

Bag-lock. *a.* A peculiar form of lock, used for satchels, etc., frequently merely a padlock. There are many varieties,— snap-latches, clasps, thumb and key bolts, etc. In the illustration are shown several varieties, which do not require explicit description.

Fig. 526.



Bag Locks.

b. A lock for mail-bags, usually some form of padlock, seal-lock, or shackle.

Bag-ma-chine'. A machine for making bags of paper or textile fabric. The term is usually applied to machines which make paper-bags for salesmen's and domestic uses. In some of these the paper is handled as in an envelope-machine, blanks of a certain size and shape being previously cut out; these are fed one at a time to the machine, either automatically or by hand, and are gummed, folded, and delivered in a pile. In other machines, the paper is made up into a hollow tube, like a stove-pipe, and is fed to the machine which makes an oblique cut, forming a flap which doubles over to close the bottom of the bag at a subsequent operation. See PAPER-BAG MACHINE.

Looms are constructed specially for making seamless bags, having a circular *shed* for that purpose. After making the length of two bags, the sheds are united, so that the tubular portion is closed and a single web of double thickness is formed. A couple of inches of this is enough, and by a transverse midway cut this double portion, thus divided, forms the

closure of two bag-bottoms. The double bag-length of the tubular portion is also transversely divided midway, the cut forming the mouths of two bags.

Bag-net. (*Fishing.*) A landing-net, or net bag-shaped, for sweeping a stream, or to be set in a stream to catch fish.

Bag'nette. (*Architecture.*) A small molding, like the astragal. When enriched with foliage, it is called a *chaplet;* when plain, a *head.*

Bag'pipes. An ancient Greek and Roman instrument. The leathern bag receives air through a valved tube from the lungs or a bellows, and is squeezed by the arm to drive the air into the pipes, which are operated by the performer. The *bass* pipe is called the *drone*, and the *tenor* or treble pipe the *chanter.* It is now considered a Scotch or Irish musical instrument, though Nero is reported to have solaced his gentle mind with its strains. Formerly common throughout Europe, it is now nearly restricted to Scotland, Ireland, parts of France, and Sicily.

It is the common country instrument of the Punjaub. The Sikh instrument rather resembles the Italian *pfiferari* than the pipes of the Scottish Highlanders.

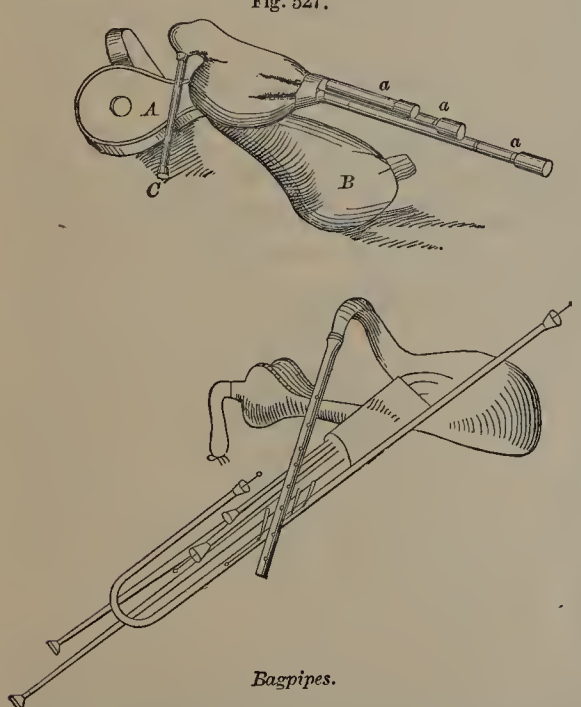
"After dinner we had a fellow play well upon the bagpipes, and whistle like a bird exceeding well."—*Pepys's Diary*, May, 1661.

Its notes are remarkable for power rather than sweetness, and require uncommon skill in the performer to render them even moderately pleasing to a cultivated ear, unless from the force of habit or the associations connected with the instrument. *De gustibus non est disputandum,* — the Romans flavored their sausages with asafetida.

Pipers are still attached to the Highland regiments in the British service.

The antiquarian notices of the instrument are in the *Musurgia* of Luscinius, 1536, and in "Don Quixote."

Fig. 527.



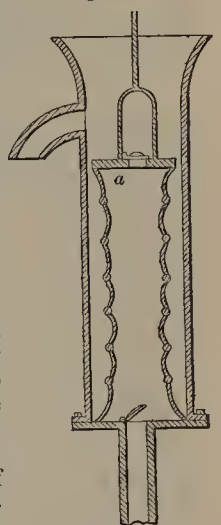
Bagpipes.

The Irish bagpipe was originally the same as the Scotch, but they now differ in having the mouthpiece supplied by the bellows *A*, which, being filled by the motion of the piper's arm, to which it is fastened, fills the bag *B;* whence, by the pressure of the other arm, the wind is conveyed into the *chanter C*, which is played on by the fingers like the common pipe. By means of a tube the wind is conveyed into drones *a a a*, which, being tuned at octaves to each other, produce a kind of cronan or bass to the chanter.

The lower cut represents the improved or union pipes, the drones of which, tuned at thirds and fifths by the regulator, have keys attached to them so as to produce chords, parts of tunes, or whole tunes, even without using the chanter. Both drones and chanter may be rendered quiescent by stops.

Bag-pump. (*Hydraulics.*) A form of bellows-pump in which the valved disk *a*, which takes the place of the bucket, is connected with the base of the barrel by an elastic bag distended at intervals by rings. It is described by Dr. Robinson in his "Mechanical Philosophy." It is much older, however, than this work, and has been invented again and again, from time to time.

Fig. 528.



Bag-Pump.

Bag-reef. (*Nautical.*) The lowest reef of a sail.

Bags. (*Porcelain.*) The flues in a porcelain oven which ascend on the internal sides and enter the oven at elevated points, so as to heat the upper part. See OVEN.

Bag-tie. See BAG-FASTENER.

Bag-weigh'er. A form of steelyard adapted for this purpose. See STEELYARD.

Bail. The arched handle of a kettle or bucket, to which it is usually connected by loops called *ears*, on the latter. The ends are usually bent around the ears, so as to be permanent, though loosely attached; but sometimes the bail is jointed, and adapted to be hooked to the ears as occasion may require.

The bails of common wooden buckets, such as are used in the house or sugar-camp, have their hooked ends inserted into perforated metallic plates, or *ears*, which are tacked to the staves.

The crane-ladle of the foundry has a *bail;* the smaller ladles have crutched handles.

Bails. (*Nautical.*) The frames that support the awning or tilt of a boat.

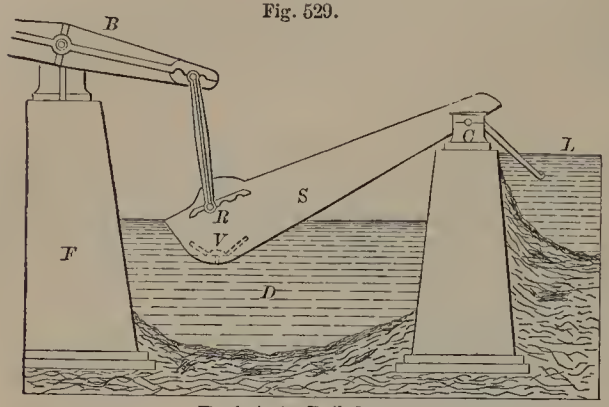
Bail-scoop. A scoop or pivoted trough, designed for draining bodies of water.

That shown in the cut was contrived by Mr. W. Fairbairn, and is adapted to be worked by the single-acting Cornish engine.

The scoop *S* turns on a center at *C;* its other end is connected at *R* to the end of the engine-beam *B*, supported on a suitable foundation *F*. *D* is the drain, and *L* the level of the water in the river or place of discharge. The stroke of the engine raises a weight suspended from the beam and depresses the end *R* of the scoop, into which water is admitted through the upwardly opening valves *V*. The weight then descends by its own gravity, elevating the immersed end of the scoop sufficiently to discharge its contents into the water at *L*. The dip may be regulated by shifting the connecting-rods.

The scoop is made of boiler plate-iron, and is 25 feet long and 30 wide, with two partitions across it to strengthen the sides and afford bearings for the valves. Seventeen tons of water can be raised at each stroke by this machine, and with an engine of 60-horse power it will do a duty equal to three pounds of coal per horse-power an hour.

Fig. 529.



Fairbairn's Bail-Scoop.

Bait-mill. A machine used by the "Bank" fishermen for cutting fish into bait. It is an oblong wooden box, standing on one end, and contains a roller armed with knives, and turned by a crank on the outside.

It resembles in form and operation a *sausage*-cutting machine, but delivers a coarser product.

Baize. (*Fabric.*) A coarse woolen fabric with a long nap, principally used for covering tables, screens, etc. First made at Colchester, England, in 1660.

"Bought me a new black baize waistecoate, lined with silk." — *Pepys*, 1663.

"Sir Thomas Clifford talked much of the plain habits of the Spaniards: how the king and lords themselves wear but a cloak of Colchester bayze, and the ladies mantles, in cold weather, of white flannell; and that the endeavours frequently of setting up the manufactory of making these stuffs there, have only been prevented by the Inquisition." — *Ibid.*, February, 1667.

Ba-la-lai'ka. (*Music.*) A musical instrument of the bandour kind, of very ancient Sclavonian origin. It is in common use both with the Russians and Tartars. According to Niebuhr, it is also frequent in Egypt and Arabia. The body of it is an oblong semicircle, about six inches in length, with a neck or finger-board of two feet. It is played on with the fingers, like the bandour or guitar, but has only two wires, one of which gives a monotonous bass, and by the other the air is produced.

Bal'ance. The word *balance* is applied to many things: some in reference to their resemblance to the oscillating beam of the scales, such as the *balance-beam* or *working-beam* of some forms of steam-engines; the *balance-handle* of a table-knife, which is weighted to lift the blade from the table-cloth; the *balance-beam* of a crane whose jib is poised on the best; the *balance*, or pivoted beam of one form of electrometer; the *balance-thermometer*, which is poised on a stem, and is thrown out of equipoise by fluctuations in the length of the column of contained mercury.

The *balance-cock* of a watch affords a bearing for the upper pivot of a watch-balance.

The *balance-plate* and *balance-ring* are parts for sustaining the upper pivot of a watch-balance. They differ in shape, but that is their function.

The *balance-spring* is the hair-spring which gives the recoil motion to the oscillating *balance-wheel*, whose pulsations determine the rate of movement of the timekeeper.

The *balance-verge* is the arbor of the balance, and carries the pallets which act upon the scape-wheel.

The *balance-weight* is a shifting weight to poise the balance, or a counterweight to balance the weight of other attached parts, as in the driving-wheel of a locomotive, etc.; or a weight to partially counterbalance the weight of a valve, and enable it to be lifted more readily.

The *electric balance* is a form of electrometer.

The *hygrometric balance* is a form of hygrometer, in which the absorption of moisture destroys the equipoise of a balanced beam.

The *hydrostatic balance* is a modification of the ordinary balance, for the purpose of obtaining specific gravities.

The *steam-balance* is the ordinary safety-valve which has a weighted lever. It was invented by the illustrious Dr. Papin, of Blois.

The *torsion-balance* is a delicate electrometer, in which a horizontal bar is suspended from a wire which is twisted by the magnetic attraction or repulsion.

The specific-gravity balance was due to the discovery of Archimedes.

The "Book of the Balance of Wisdom," by Al-Khâzinî, of the twelfth century, is a treatise on the specific-gravity balance, which he credits to Archimedes, narrating the story of Hiero and the Syracusan goldsmith; and which, as he says, "is founded upon geometrical demonstrations, and deduced from physical causes, in two points of view: 1. As it implies centers of gravity, which constitute the most noble and elevated department of the exact sciences, namely, the knowledge that the weights of heavy bodies vary in proportion to the differences in distance from a point in common, — the foundation of the steelyard; 2. As it implies a knowledge that the weights of heavy bodies vary according to difference in rarity or density of the liquids in which the body weighed is immersed, — the foundation of the balance of wisdom." The book of the Saracenic philosopher was translated by Chev. Khanikoff, Russian Consul-General at Tabriz, Persia; and an English translation is in the sixth volume of the "Journal of the American Oriental Society," New Haven, 1860.

In connection with the subject of the great relative weight and accepted theory of the value and purity of gold, the pious Moslem enters the following protest: —

"When the common people hear from natural philosophers that gold is the most equal of bodies, and the ore which has attained to perfection of maturity at the goal of completeness, in respect to equilibrium [stability of character, under circumstances which dissolve or destroy other metals], they firmly believe that it has gradually come to that perfection by passing through the forms of all [other] bodies, so that its gold nature was originally lead, afterwards became tin, then brass, then silver, and finally reached the perfection of gold; not knowing that the natural philosophers mean, in saying so, only something like what they mean when they speak of man, and attribute to him a completeness and an equilibrium in nature and constitution, — not that man was once a bull and was changed into an ass, and afterwards into a horse, and after that into an ape, and finally became man."

This has been wrongly quoted; it is not fair to call Al-Khâzinî a Darwinian.

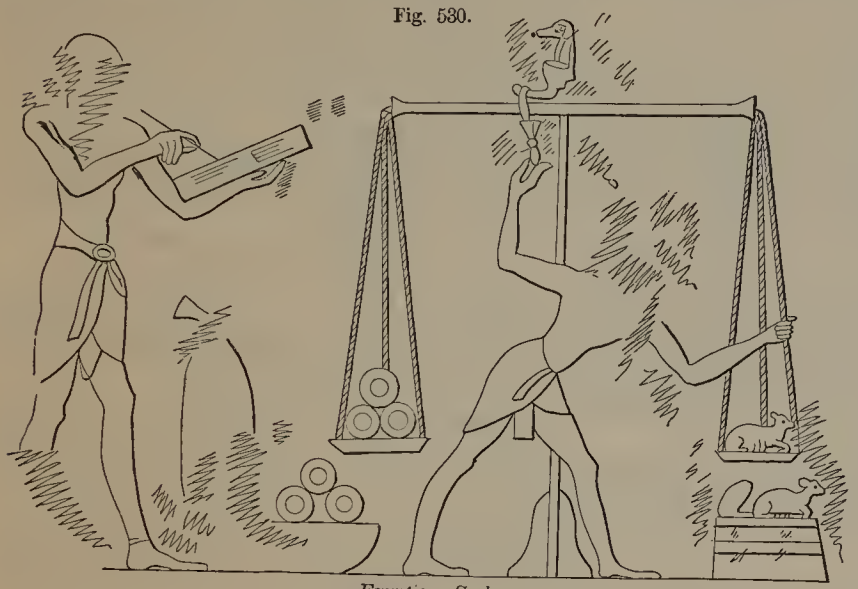
The balance of Archimedes was a beam, with bowls suspended from fixed points at each end, and a movable weight adjustable on one arm of the beam, which was graduated from the fulcrum to the point of suspension of one of the bowls. By adjustment on the arm, the weight was made a counterpoise equal to the difference between the weights in the respective bowls.

The balance of Mohammed Bin Zakazîyâ differed from that of Archimedes by the introduction of the

indicator-needle attached to the beam, and called by the Arabs the *tonguo*, and by the substitution of a movable suspended scale for the movable weight to balance the difference between scales. Both were described and exhibited by Al-Khâzinî in his work above referred to.

1. The original form of weighing scales was probably a bar suspended by the middle, and with a board or shell suspended from each end, one to contain the weight, and the other the matter to be weighed. Parts of the original picture (Fig. 530)

Fig. 530.



Egyptian Scales.

are defaced by time, as indicated. An ancient Egyptian balance, consisting of a wooden beam and a piece of lead at the end for a weight, was found at Sakkarah.

In early times, before the coinage of money, the precious metals were weighed out, and the duty of weighing was regulated by the municipality, and attended to by public weighers, as we see in the Egyptian monuments and read in classic literature. Abraham paid for the land he bought in silver, *weighing* it out to Ephron, 400 shekels of silver.

The sons of Jacob also paid for the wheat they bought in Egypt at a given price in metal, weighed out to the officers of Joseph.

For the early uses and gradual improvement in the production of coin, see COINAGE.

The "balance" of the Bible was similar to that of Egypt, the ends of equal length, and the beam suspended by its mid-length. The frequent reference to false and unequal balance shows that the lever-balance on the "steelyard" principle was unknown to them.

The lever of unequal lengths on each side of its point of suspension affords a convenient mode of determining weights of various objects with but a single weight, the object being suspended from the end of the shorter arm, while the bob is shifted along the graduated longer arm until it forms an exact counterpoise for the object weighed. This is called the *steelyard*, probably from its material and former length in England, and is also known as the *Roman Balance* (*Statera*). See STEELYARD.

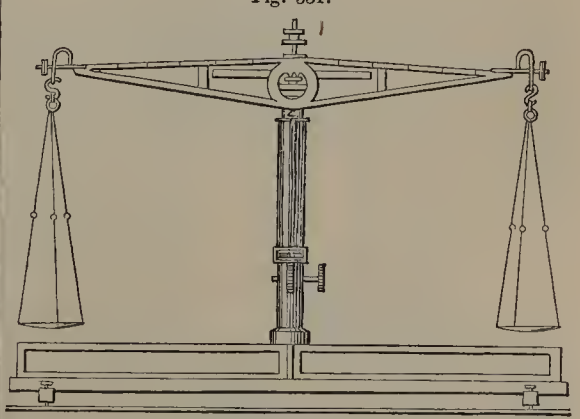
Balances for delicate operations, such as those used in assaying and chemical manipulation, are made with extreme care. The beam should be as light as possible consistent with inflexibility; for not only the inertia, but also the friction, is increased in proportion to the weight, and the sensibility consequently diminished. A cylinder of steel passing at right angles through the center of the beam forms the axis; and its extremities, ground into sharp edges on the lower side, serve as the points of support. The two edges must be accurately in the same straight line, and turn on smooth planes of agate or polished steel, carefully leveled. The pans should likewise be suspended from the extremities of the beam by agate planes resting on knife-edges. A needle or tongue is usually attached to the beam, pointing directly upward or downward, when the beam is horizontal, for the purpose of indicating the deviations of the beam from the horizontal position, on a graduated scale. It is better, however, to bring the arms to terminate in points, and to place a divided scale behind each. In this way the slightest deviation of the beam will be rendered evident, if the zeros of the scales be placed exactly in the same level. The scale is indispensable, because the balance, if very sensitive, would require a long time to come to rest; but it is known to be poised when the excursions of the needle on both sides of the zero of the scale are equal. In order to preserve the knife-edges, the beam, when not in use, is supported on rests. Props should also be placed under the pans when loading or unloading the balance. The whole apparatus must be placed under a glass case, to protect it from the disturbing influences of currents of air.

The sensitiveness of a balance constructed with due care may be carried to almost inconceivable extent.

Analytical balances are usually made to carry 1,000 grains in each pan, and to turn with the $\frac{1}{10000}$ part of a grain.

There are several large balances in use in the English mint, calculated to weigh from 1,000 to 5,000 ounces Troy. Some of them turn with $\frac{1}{10}$ of a grain, when loaded with 1,000 ounces in each scale, or with $\frac{1}{9000000}$ part of the weight.

Fig. 531.



Coin Balance.

To the mode of suspending the beam and the scales

more attention has probably been directed than to any other part of the balance.

Of some of the European balances, —

Fox's beam has pivots, the conical ends of which play in hollow agate cones of larger angle.

Oertling's beam is coated with platinum or palladium, the knife-edges and planes being of agate, and the instrument proof against acid fumes. The knife-edges are let into dovetailed notches in the beam. The beam is graduated, so that small differences of weight can be determined by placing a small platinum wire weight on one of the divisions of the graduated beam.

Steinheil suspends the beam by wires or silk cords. In another of Steinheil's, the beam carries two small steel spheres in the middle, resting on a steel plane, and a sphere at either end, upon which rest the plane or slightly convex spherical surfaces of the plates, from which the pans are suspended.

Among the modes of delicately adjusting the parts to obtain perfect equilibrium may be cited : —

In Dover's the final adjustments in the direction of the length of the beam, and in a direction perpendicular to it, are affected by a cut at each end of the beam, making an angle of 45° with the axis of the beam, and capable of being widened by a screw.

In the *American* balance the socket in which one of the extreme knife-edges is fixed moves in a slit in the direction of the length of the beam, and is adjusted by means of two screws.

In Oertling's the adjustment of the distance of the extreme knife-edge from the middle knife-edge is effected by a vertical cut in the metal of the beam, capable of being slightly widened or contracted by screws.

Among the modes of checking the oscillation of the pans may be mentioned Dolberg's, which consists of hair-brushes turning on a handle, and ascending till the ends of the brushes touch the under side of the pan. The mode of obtaining quiescence of the pan in the periodical intermittence of the coin-weighing apparatus is by a depressed ivory point above and an agate point beneath.

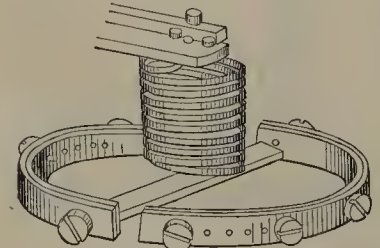
In Fox's balance the beam is brought to zero by the attraction of a magnet.

The sensitiveness of a balance depends (after friction has been reduced to a minimum), first, on the proximity of the center of gravity to the point of suspension on which the beam swings ; and the center of gravity must be directly below the point of suspension. Secondly, on the fact that all three knife-edges are in the same plane, to prevent the farther lowering of the center of gravity when the beam is loaded. Thirdly, on the rigidity of the beam, to prevent a similar lowering by springing.

See Faraday's "Chemical Manipulations" for suggestions in construction and management of delicate balances used in quantitative analysis.

See also Coin-weighing Machine ; Counter Scales; Micrometer Balance ; Platform Scales ; Spring Balance ; Steelyard ; Weighing Machine.

Fig. 532.



Chronometer Balance.

2. (*Horology.*) The oscillating or pendulum wheel of a watch, which gives the pulsations. Its axis is the verge.

In the earliest clocks it was in the form of a balance, and not of a wheel. It consisted of two weighted arms, oscillating on a vertical axis. The clock of Henry de Wick, made in 1379 for Charles V., had a balance of this description. The balance, so far as watches are concerned, is a wheel driven in one direction by the mainspring acting through the train of gearing, and returned by the force of the hair-spring. While watches of the various kinds have balances, their escapements generally constitute their distinguishing features by which they are named and known. See Escapement.

In regulating a watch, the length of the beat of the balance is increased or shortened to make the watch go slower or faster. This is done by letting out or taking up the hair-spring. See Hair-spring : Compensation Balance.

The clock or watch balance consists of —

The *rim.*

Verge ; spindle or arbor.

Spring ; which gives the recoil movement.

Regulator ; determines the length of spring involved in the movement.

Cock ; affords a bearing for the upper pivot.

Potance ; a step for the lower pivot.

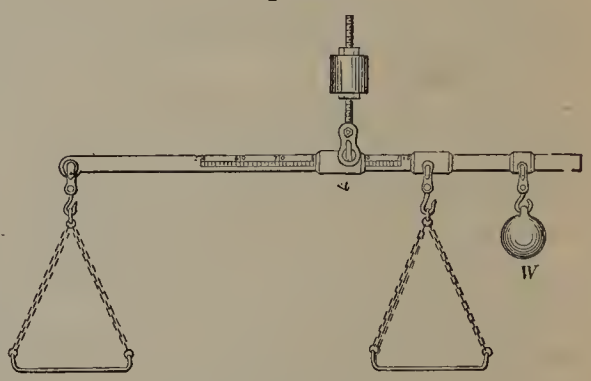
Pallets ; the plates on the verge, which engage the *scape-wheel.*

3. (*Electricity.*) A term applied to a device for measuring the resistance of an element of an electric circuit. Also known as a Bridge.

Bal'ance, Al-loy'. Robert's Alloy Balance is intended for weighing those metals whose proportions are stated decimally, being constructed on the principle that weights *in equilibrio* are inversely as their distances from their points of support.

The point of suspension, *a*, of the balance is adjusted until the arms are respectively as the two stated proportions, — say 17 tin to 83 copper. The half of

Fig. 533.



Robert's Alloy Balance.

the beam is divided into 50 equal parts, numbered from the one end, and, the point of suspension being adjusted proportionally, the weight *w* is brought to a position where it enables the beam of the empty balance to stand *in equilibrio.* A quantity of copper being then placed in the scale suspended from the short arm will be balanced by the proportionate quantity of tin in the other scale. See table in Alloy, for converting fractions of a pound to decimal proportions.

Bal'ance-bar. (*Hydraulic Engineering.*) A heavy beam bolted to the miter-post of a canal-lock gate, and resting upon the heel-post of the same. It extends over the wharf or pier when the gate is closed, and has two uses,— it forms a lever by which the gate is swung on its pintle, and it partially balances the outer end of the gate.

Bal'ance-bob. A weight on the inner end of a working-beam, to counterbalance the weight of the plunger-piston. The *balance-bob* of the Wicksteed

engine of the East London water-works is a receptacle of ballast, weighing about 89,600 pounds.

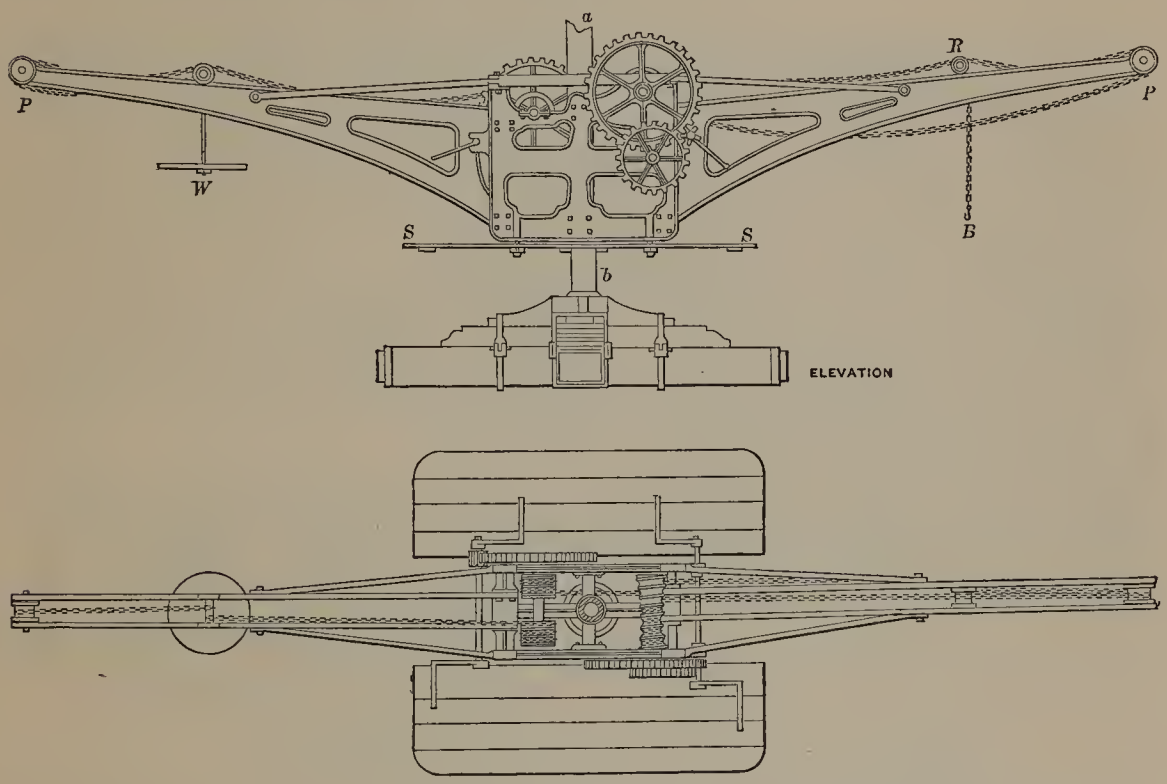
Bal'ance-bridge. A lifting bridge with a counterpoise. A BASCULE BRIDGE, which see.

Bal'ance-crane. A crane having two arms, one of which is provided with arrangements for counterpoising, in whole or part, the weight to be raised by the other.

The following is a description of that employed by Stevenson in the erection of the Skerryvore Lighthouse.

a b is a portion of a cast-iron pipe or pillar erected in the center of the tower, and susceptible of being lengthened as the tower rose, by means of additional pieces of pillar let in by *spigot and faucet joints*. On this pillar a frame of iron was placed, capable of revolving freely round it, and carrying two trussed arms and a double train of barrels and gearing, worked by men standing on the stages *S S*, which revolved round *a b*, along with the framework of the crane from which they hung. On the one arm hung a cylindric weight of cast-iron, *W*, which could be moved along it by means of the gearing, so as to increase or diminish by leverage its effect as a counterpoise; and on the other was a roller *R*. The roller was so connected with the weight on the opposite arm as to move along with it, receding from or approaching to the center pillar of iron in the same manner as the weight did. From the roller hung a sheave, over which a chain moved, with a hook *B* at the end for raising the stones. When a stone was to be raised, the weight and the sheave were drawn out to the end of the arms at *P* of the crane, which projected over the outside of the walls of the tower; and they were held in their places by simply locking the gearing which moved them. The second train of gearing was then brought into play to work the chain which hung over the sheave, and so to raise

Fig. 534.



Balance-Crane used at Skerryvore.

the stone to a hight sufficient to clear the top of the wall. When in that position, the first train of gearing was slowly unlocked, and the slight declivity inwards from the end of the arms formed an *inclined plane*, along which the roller carrying the sheave was allowed slowly to move (one man using a break on the gearing to prevent a rapid run), while the first train of gearing was slowly wound by the others, so as to take up the chain which passed over the sheave, and thus to keep the stone from descending too low in proportion as it approached the center of the tower. When the stone so raised had reached such a position as to hang right over the wall, the crane was made to turn round the centre column in any direction that was necessary, in order to bring it exactly above the place where it was to be *set*; and, by working either train of gearing, it could be moved horizontally or vertically in any way that was required.

Bal'ance E'lec-trom'e-ter. An instrument having the poised beam of the ordinary balance, and adapted to estimate, by weights suspended from one arm, the mutual attraction of oppositely electrified surfaces.

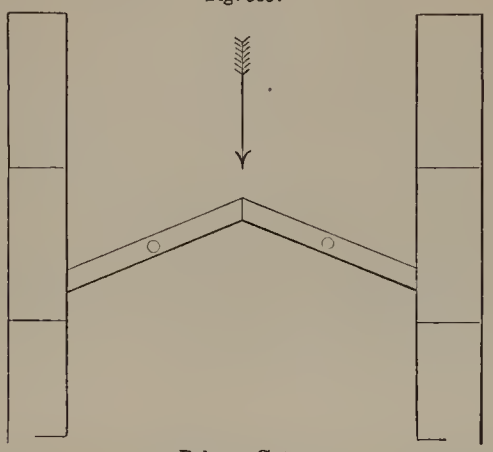
In HARRIS'S electrometer the beam is suspended from an insulated post; one scale, carrying the weight, has its seat upon a post; the other scale is a disk which is suspended above a similar disk electrized by connection with a charged Leyden jar. HENLEY'S quadrant electrometer has a pendulous pith-ball whose deflections are measured by a graduated arc.

Bal'ance-frames. (*Shipbuilding.*) Those frames of a ship which are of equal area and equally distant from the ship's center of gravity.

Bal'ance-gate. (*Hydraulic Engineering.*) A form of flood-gate which has a vertical shaft as a center. As the leaves on each side of the pintle are of equal area, a very small power is necessary to open them in whichever direction the water may be pressing. By giving a preponderating area to the inner

leaves of the gate, they may be made self-opening or self-closing as the current sets in or out of a channel. In this form they are commonly used as sluice-gates in Holland.

Fig. 535.



Balance-Gates.

Bal'ance, Hy'dro-stat'ic. See SPECIFIC-GRAVITY BALANCE.

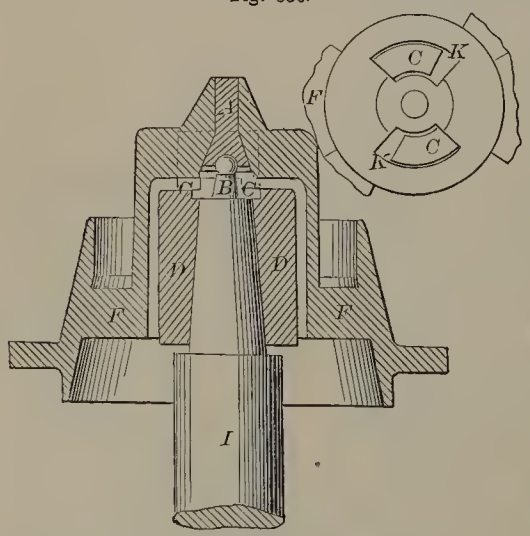
Bal'ance-lev'el. (*Surveying.*) An instrument suspended by a ring. When in equilibrium, two sights, properly fitted to the instrument, show the line of level.

Bal'ance-knife. (*Cutlery.*) A table-knife, of which the blade and handle counterbalance each other, so that the blade may not touch and soil the cloth.

Bal'ance-reef. (*Nautical.*) In a square sail, a diagonal reef-band from the outer head-earing to the tack. In a fore-and-aft sail, it extends from near the outer point of the upper horizontal reef-band to a point higher up at the inner edge of the sail.

Bal'ance-rynd. (*Mill.*) An iron bar stretching across the eye of the runner, and by which it is poised on the top of the spindle. In the illustration, *I* is the *spindle* of the runner; *B* the *cock-head*, on which the *balance-rynd F F* is poised. The latter has a capacity for rocking back and forth on the

Fig. 536.



Balance-Rynd.

spindle to a given extent, as the *runner* finds its adjustment on the *bed-stone*. The driving-block *D D* sits on the square of the spindle, and the driving-lugs *C C* bear in the slots of the balance-rynd, and drive the stone when the spindle *I* is rotated.

Bal'ance-sec'tion. (*Shipbuilding.*) One of a pair of vertical cross-sections, one near each end of the vessel, which are designed after the midship section and leading water-line.

Bal'ance Ther-mom'e-ter. A thermometer poised on an axis, and having ether and mercury in the respective ends. When an unusual heat occurs, the ether is expanded, and drives the mercury farther towards the end, which tips the instrument and sounds an alarm. A form of *fire-alarm*.

Another form of *balance thermometer* is an inverted tube, which acts as a counterpoise to a window, register, or damper. The upper end of the tube has an air-bulb, the lower end of the stem containing mercury, into a cup of which the end is submerged. As the temperature increases, the air expands, displaces the mercury, the tube rises, and the window or damper is moved. The converse operation takes place when the temperature falls. See THERMOMETER.

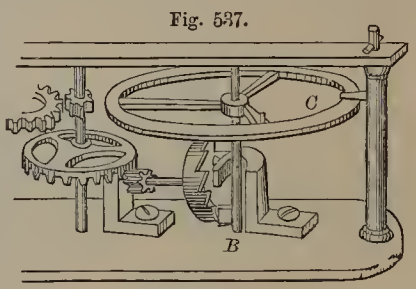
Bal'ance-valve. A valve of any character in which steam is admitted to both sides, so as to render it more readily operated by relieving its pressure upon the seat. The balance *puppet-valve* has two disks of slightly differing diameter, and placed on a single stem; the steam being admitted between the two, or above and below the upper and lower disk respectively. The slight difference in size is in favor of the pressure of the valve on the seat.

The object is to secure a large opening without great resistance.

Bal'ance-vise. (*Watchmaking.*) A small tail-vise, used by watchmakers.

Bal'ance-wheel. In horology this signifies the ratchet-formed escape-wheel in the old *vertical-movement* watch. Its teeth are acted upon by the pallets of the verge *B*, which is the axis or spindle of the balance *C*, and the latter, in its oscillation, makes the time-beat, acting as the pendulum in a clock.

Fig. 537.



Balance-Wheel.

The term *balance-wheel* is sometimes applied to the *balance C*, which acts as the measurer of time, and *balances* or regulates the rate by applying its pulsations to intermit the action of the spring. So the term *balance-wheel* has gradually been conferred upon fly-wheels which confer regularity of motion to the machinery to which they are applied.

The term *balance* is derived from its original form, consisting of weighted arms upon an oscillating axis, and having a semblance to the beam of the balance when it oscillates on its pivot or bearings. This was the form of the balance in Henry de Wick's clock, constructed for Charles V., in 1379.

Bal'ance-wheel En'gine. (*Horology.*) An instrument for forming the ordinary balance-wheel of a watch, which consists of a four-spoked, full-rimmed wheel of steel, and is made of a steel disk from which the segments are punched out, the *crossed wheel* being finished by a file.

Bal'ance-wheel File. (*Horology.*) Or *Swing-wheel File*. A file adapted to cut out the sectors from the circular steel plate, which forms the blank for the balance-wheel.

Bal'co-net. A low, ornamental railing to a door or window, projecting but slightly beyond the sill or threshold.

Bal'co-ny. 1. (*Architecture.*) A projecting stage or platform on the outside of a building, usually supported by consoles or columns, and furnished with a rail or other enclosure.

2. (*Shipwrighting.*) The stern gallery of a ship.

Bal'da-chin. (*Architecture.*) A canopy supported by columns, and raised over altars, tombs, etc.

Bale. A bundle of stray, hay, or other material, put up in compact form for transportation or storage.

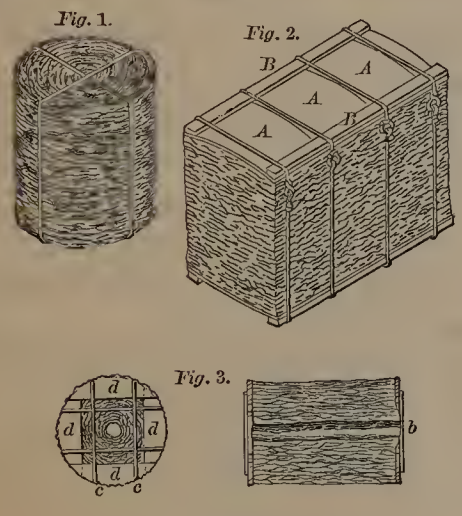
Many ingenious devices for putting up forage rations and cut-stuff for feed have been devised from time to time, especially since the United States military stations have been so widely established.

The bale 1 is made up of a roll or rolls of hay or straw, laid in coils, and fastened by cords or wires crossing it longitudinally at right angles.

In 2, the top and bottom of the bale are covered by transverse strips *A A*, curved so as to shed water, and the edges are protected by longitudinal strips *B B*.

3 shows a cylindrical bale, having a central hollow *b* extending from end to end. The ends are strengthened by segmental strips *d d*, which protect the edges, leaving the body of the bale open to free ventilation. Longitudinal ties *c c* bind the whole together.

Fig. 538.



Bales.

Ba-leen.' The plates of fibrous material with a bristly fringe, which depend from the upper jaw of the *right whale* (*Balæna mysticetus*). There are about 200 of these plates on each side of the mouth in the outer row. These are from 10 to 15 feet in length, and about one foot broad at their base. An inner row of smaller subsidiary plates is arranged obliquely. The material is called *whalebone;* but the word is quite inappropriate, as it is not of the nature of bone.

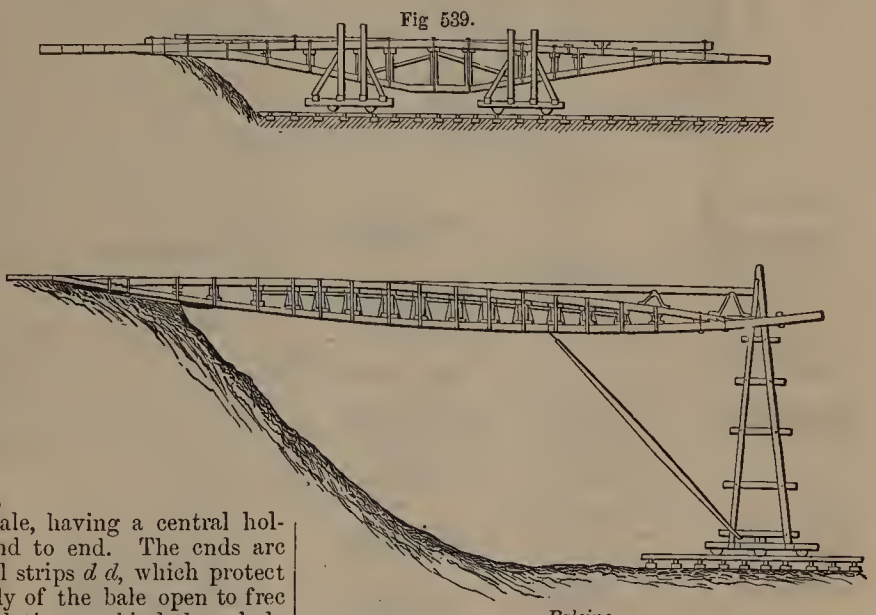
The material is used for the ribs of umbrellas, stiffening for corsets, for chimney and street brooms, elastic brushes, heckles for flax-brakes, and is split into splints for plaiting like straw.

Strips of *baleen* have been aggregated by pressure, moisture, and heat, so as to become agglutinated, and thus form larger articles, such as walking-canes. Kortright's English Patent, 1841.

Artificial baleen is made in Germany, and consists of rattans impregnated with a strong black varnish. It is called *wallosine.*

Ba-leine'. A movable scaffold, employed in France to facilitate the tipping of the wagons in railroad embankments.

Fig 539.



Baleine.

It consists of two trussed beams, which are laid with rails along the top, one end resting on the ground at the commencement of the embankment, or at the battery-head of an embankment in course of formation; the other end of the *baleine* rests on a wheeled carriage, or an auxiliary railway, the rails of which are taken up at one end as the other progresses. When a car is tipped at the battery-head, the contents are discharged between the rails, and it is pushed to the other end of the *baleine.* The same plan is followed with the rest of the loaded cars until the *baleine* is full. The empty cars are then coupled and withdrawn by the locomotive.

Bale-tie. A device for fastening the ends of the hoops by which bales of cotton are held in compact form.

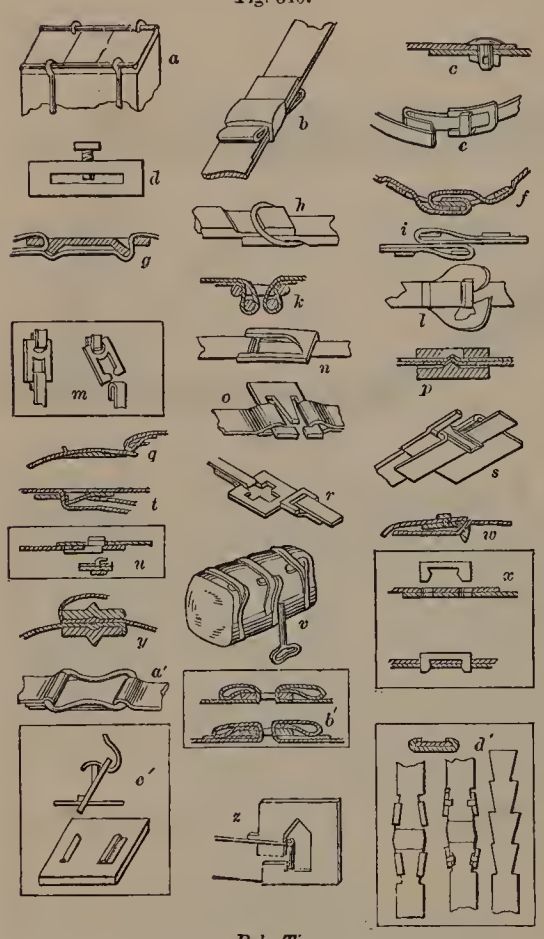
The annexed cut shows 29 of these devices, which are selected from a much larger number, to illustrate, not only the devices themselves, but also the number of modes in which so apparently small a problem may be solved.

The name and date are simply given, as the construction and operation will be generally understood without special explanation.

a.	Sabatier	(English),	1796.
b.	Blair	"	1802.
c.	Breck	"	1807.
d.	Smith		1849.
e.	McComb,	June 15,	1856.
f.	Broad,		1850.
g.	Swett,	Oct. 23,	1866; reissued May 7, '72.
h.	McComb,		1850.
i.	Cook,	March 2,	1858.
k.	Brodie,	" 22,	1859.
l.	Beard,	Oct. 16,	1866.

m.	JORDAN,	Aug.	28, 1870.
n.	MORRIS,	April	6, 1869.
o.	ADAMS,	Feb.	20, 1872.
p.	PEYTON,	July	18, 1871.
q.	LECKY,	Oct.	29, 1867.
r.	SECHLER,	March	19, 1867.
s.	SHEPPARD,	Aug.	22, 1871.
t.	LATTING,	Dec.	18, 1866.
u.	ONIONS,	June	5, 1866.
v.	LEE,	Oct.	16, 1866.
w.	MILLIGAN,	Nov.	6, 1866.
x.	MERRITT,	April	10, 1866.
y.	QUANT,	Oct.	28, 1865.
z.	MCCOMB,	Jan.	29, 1861.
a'.	SEAVER,	Oct.	23, 1866.
b'.	MCCOMB,	"	23, 1866.
c'.	WAILEY,	"	9, 1866.
d'.	GRIDLEY,	"	23, 1866.

Fig. 540.



Bale-Ties.

In connection with the subject of ties for bales may be mentioned the devices for baling cut hay, and for baling feed and forage rations, to condense their bulk for transportation. The latter are especially intended for military and emigrant purposes.

One plan is briefly as follows : —

The hay is carried by an endless apron to a rotary cutter driven by power, and which, cutting past a fixed blade, chops the hay into pieces of from three fourths of an inch to one and a half inches in length. After this it passes through a winnowing apparatus, which abstracts all dust and dirt therefrom, and then between crushing-rollers, which crush it flat and render it soft and flexible ; in this condition it is placed in a strong press and compressed into a bale of great solidity and compactness, which, when properly hooped or banded, is ready for transportation. By these means the size of bale for a given weight of hay is materially reduced, while the thorough removal of dust, etc., and the softening of the material from the crushing to which it has been subjected, increase its value for feeding purposes.

The bales contain about nine cubic feet, and weigh 200 pounds.

In baling forage rations, a feed of corn is placed in a feed of hay, and the whole condensed into the shape of a large brick.

Bal'ing-ma-chine'. (*Hydraulic Engineering.*) An apparatus consisting of a square bucket, sliding on a nearly vertical rabbeted beam, dipping at its lower position into the water in the hold or ditch, and discharging its contents upon deck.

The bucket has a flap-valve at bottom, which opens when it reaches the water. It is hoisted by means of tackle. When the bucket reaches the top, a part of the slide tilts over and tips the bucket, which discharges its contents. See also BAIL-SCOOP.

Bal'ing-press. A press for condensing fibrous articles of considerable bulk into a compact form, for the purpose of shipment.

It essentially consists of a bed, inclosing sides, and a head, platen, or follower, operated by means of screws, toggles, beaters, rope and pulley, or by other mechanical devices, as will hereafter appear.

The varieties may be thus enumerated, and will be considered in their alphabetical position under the following heads : —

1. Screw press.
2. Toggle press.
3. Beater press.
4. Revolving press.
5. Hydraulic press.
6. Portable press.
7. Double-acting press.
8. Windlass press.
9. Rack and pinion press.
10. Repressing press.
11. Rolling-pressure press.

Other minor varieties and sub-varieties might be cited were there any object in multiplying definitions.

Ba-lise'; Ba-lize'. A timber frame raised as a beacon or landmark.

Balk. 1. (*Carpentry.*) *a.* A squared timber, long or short, suitable for a *beam* in a frame, a *tie* in a truss, a *girder* in a floor, a *sill* in a building, or for a *shore* or *chock* when of shorter proportions. BAULK ; BAUK ; BAWK.

b. A large timber in a frame, trestle, truss, or floor.

c. A whole timber. Technically, over 13 inches square. Half-timber is 6¼ inches square.

2. (*Military Engineering.*) A longitudinal timber of a ponton-bridge.

Ball. 1. (*Games.*) A sphere of ivory, wood, etc., used in billiards, bagatelle, croquet, and other games.

Balls for playing are made of various sizes and materials, according to their intended purpose. That, perhaps, most familiarly known, is ordinarily composed of an interior core of india-rubber, usually, if not always, made up of strips wound into spherical form, around which is wound woolen yarn, the whole being covered with leather. Many are also made wholly of india-rubber, and hollow.

Billiard-balls are made of ivory, that substance combining in the highest degree the required qualities of resiliency and durability. Ten-pin balls are of lignum-vitæ. Boxwood is preferred for croquet-balls. See also IVORY, ARTIFICIAL.

The game of ball is mentioned by Homer (*Odyssey*, viii. 372), and was credited by Plato to the Egyptians, among whom it was known in the twelfth dynasty, say 2000 B. C.

The Athenians erected a statue to Aristonicus on account of his skill in ball-playing.

Foot-ball is very much in vogue among the American Indians, large parties of whom participate in the sport. Its practice among the Indians of the Plains is well described in Catlin's "North American Indians."

Tennis was played in England in the sixteenth century. The tennis-court at St. James's was erected in 1676. This game was for many years a favorite amusement with the nobility of England and France.

The invention of billiards is ascribed to Delvigne, 1571. We find cricket first mentioned in 1719.

Croquet was introduced into England from Germany in 1830; its popularity in America hardly dates back more than a decade.

2. (*Projectiles.*) A missile to be projected from a fire-arm, *e. g.* a bullet or cannon-ball. These are made of lead for small-arms, and of cast-iron for cannon, though in countries where copper was plentiful and iron scarce, as in South America and Mexico, the former metal was employed, even when imported cast-iron cannon were used. The lack of tin, and perhaps want of skill, forbade the people of those countries to cast bronze ordnance, though they could make copper shot.

Weight of Cast-iron Balls.

Diameter in Inches.	Weight in Pounds.	Diameter in Inches.	Weight in Pounds.
1	.1377	6¾	42 34
1¼	.268	7	47 23
1½	.464	7¼	52 46
1¾	.737	7½	58.09
2	1.10	7¾	64 09
2¼	1.56	8	70.60
2½	2.15	8¼	77.31
2¾	2.83	8½	84.56
3	3.71	8¾	92 24
3¼	4.71	9	100 33
3½	5.90	9¼	108.98
3¾	7.26	9½	118 05
4	8.81	9¾	127.62
4¼	10.58	10	137 70
4½	12.54	10¼	148.28
4¾	14.15	10½	159.51
5	17.21	10¾	171.06
5¼	19.92	11	183 27
5½	22.89	11¼	195 05
5¾	26.17	11½	209 42
6	29.74	11¾	223.38
6¼	33 61	12	238.04
6½	37.81		

3. (*Printing.*) A dabber for inking type or calico-printing blocks. Its mission is nearly ended in either capacity. It consists of a piece of buckskin stuffed with wool so as to form a ball, and furnished with a handle. The corresponding device used by the engraver in spreading etching-ground is called a *dabber*.

4. (*Fabrics.*) A round cop of thread or yarn.

5. (*Metal-working.*) A spherical tool for cutting; such as those for excavating bullet-molds, carious teeth, etc.

6. (*Metallurgy.*) A loop (Fr. *loupe;* Ger. *luppe*) or mass of iron gathered into a lump in a puddling-furnace, and in a condition fit for the squeezer or tilt-hammer.

7. (*Machinery.*) *a.* A spherical valve, operated by the passing fluid, and limited as to its extent of motion by a cage, or by the size of the chamber.

b. One portion of that universal joint which consists of a ball gripped by a box and ring.

8. (*Horological.*) The weight at the bottom of a pendulum, sometimes called the *bob*.

Bal'la-hore. (*Nautical.*) A West India schooner with fore and aft sails only; the foremast rakes forward, the mainmast aft.

Ball-and-sock'et Joint. A joint formed by a ball working in a hollow cup or socket, which allows it free motion in every direction within certain limits. See Universal Joint.

Fig. 541.

Ball-and-Socket Joint.

Bal'last. 1. (*Railway Engineering.*) Gravel, broken stone, or cinders placed beneath and around the sleepers of a railroad track, forming a solid bed which will not retain water. Drainage must be provided below the *ballasting*. In England, where it is also called *metal*, two-feet bed of ballast is deemed sufficient, no water being allowed to stand within a depth of four feet below the rails.

Ballast has four duties to perform:—

a. To distribute the bearing over the surface of the earthwork.

b. To confine the track in place.

c. To permit drainage of the surface.

d. To afford a certain degree of elasticity. A solid rock sub-way is too unyielding, and injures the rolling stock. Burned clay is a fair material. Cinders, shells, and small coal are also used in certain localities.

2. (*Nautical.*) Weight in the bottom of a boat or the hold of a vessel, to keep it upright in the water, and prevent its being upset by the force of the wind or the weight of its *top-hamper*.

On board vessels of war *pig-iron* is generally employed for ballast; that of the British navy consists of iron pigs of about 300 pounds each.

Means have been provided for using water as ballast. Its evident convenience, both as to accessibility and facility of removal, have induced considerable pains to be incurred in devices for containing it.

The employment of water-tight bags has been several times attempted. These, when empty, are stored away in large boxes, and when required are spread out in the hold and filled by a connecting hose. There are evident objections to this mode.

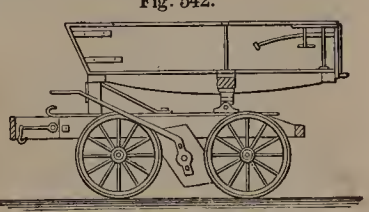
Iron tanks have been built into the ship, occupying positions on the floor, and at the stem and stern next to the *dead-wood*.

Tanks made by two bulkheads across the vessel have also been used. These are made of such a size that they may be used for coals or cargo when the ballast is not required. The reservoir, whatever form it may have, must be quite full, to prevent the swashing of the water, and the bulkhead tank has been found difficult to fill and keep tight.

The plan suggested by Grantham, of Liverpool,—a distinguished authority on the subject,—is specially adapted for ships carrying coal, where little or no back freight is to be had. See Grantham's "Iron Ships," Weale's Series.

Bal'last Car or Wag'on. (*Railway Engineering.*) A dumping-car for transporting ballast for the road-bed.

Fig. 542.



Ballast Car (English form).

In the illustration is seen the

English form, having a capacity for dumping to the rear or towards either side. See DUMPING-CAR.

Bal'last-en'gine. 1. (*Hydraulic Engineering.*) A dredging-machine for raising shingle from the bottom of a river for ballasting vessels.

2. (*Civil Engineering.*) A steam-engine employed in excavating and shoveling gravel for ballasting a road-bed.

Bal'last-heav'er. (*Hydraulic Engineering.*) A dredging-machine for raising ballast from a river-bed.

Bal'lasting. (*Engineering.*) *a.* The gravel or broken stone, known as *metal*, which forms the road.

b. The material beneath and around the sleepers of the *permanent way* of a railroad. See BALLAST.

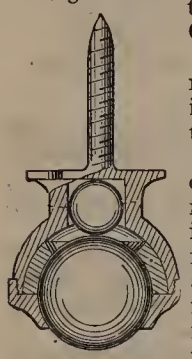
Bal'last-light'er. (*Nautical.*) A barge for conveying ballast to a vessel.

Bal'last-shov'el. (*Nautical.*) A square-bodied and spoon-pointed iron shovel.

Ball-cal'i-ber. A ring-gage for testing the diameter of gun-shot on board ship.

Ball-cart'ridge. For small-arms; powder and ball in an envelope. In contradistinction to *blank*-cartridge. See CARTRIDGE.

Fig. 543.

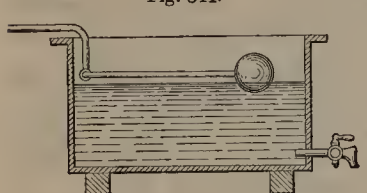


Ball-Caster.

Ball-cast'er. A caster for furniture, etc., having a sphere or ball instead of a common roller at bottom.

Ball-cock. A faucet which is opened or closed by means of a ball floating on the surface of the water in the vessel, allowing the cock to remain open until the water has attained a certain hight, when it is closed by means of a rod connection with the rising ball, falling again as water is withdrawn from the vessel. It constitutes an automatic arrangement for keeping the water at a certain hight. It is useful in cisterns, water-backs, boilers, etc., where the supply is constant, the demand intermittent.

Fig. 544.



Ball-Cock.

Ball-gud'geon. A pivot of a spherical form which permits lateral deflection of the arbor or shaft, while retaining the pivot in its socket.

Ball'ing Fur'nace. (*Metallurgy.*) A furnace in which *piles* or *fagots* of iron are heated so as to form balls for rolling. In the *puddling-furnace*, pig-iron is boiled to drive off certain impurities, and the iron therein is formed into balls by the *rabble* or *paddle* of the puddler, so as to be ready for the shingling-hammer or the squeezer which drives the slag from the bloom. At the same heat the iron may be rolled and become a merchantable article of bar-iron; but with some qualities of iron, and for the production of the finer varieties of bar and sheet iron, the bar from the first rolling is cut up by the shears, and made into piles or fagots, which are reheated to form *balls* for re-rolling.

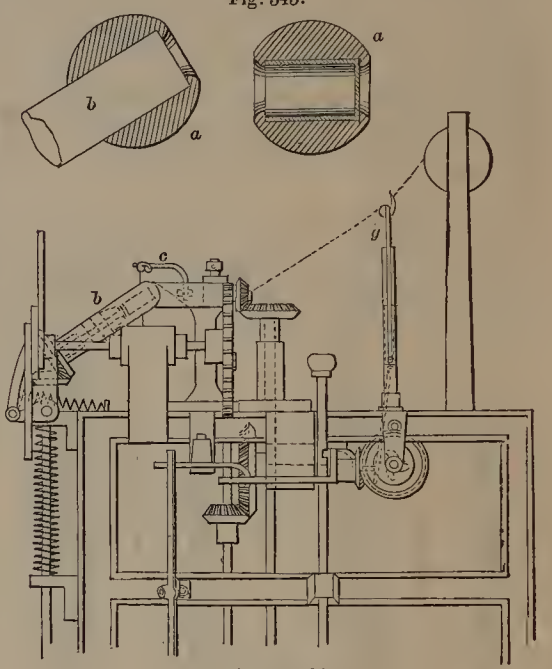
The furnace resembles a puddling-furnace, with the exception that it is not designed for stirring and puddling, but the *piles* or *fagots* are laid upon the floor of the reverberating chamber, and are there heated without running together, each being withdrawn as it attains the required condition. The bottom is made up from time to time with sand. It is not a *mere* reheating, but the action of the fire and the admission of regulated quantities of air remove certain impurities which have resisted the previous operations.

Ball'ing-gun. An instrument for administering medicine rolled into balls to horses. It consists of a partially exhausted tube, on the end of which the ball is held by pressure of air, and from which it is released by a piston when the ball is fairly within the œsophagus.

Ball'ing-i'ron. (*Farriery.*) A hook for clearing a horse's feet from the balls of snow, etc., retained by the shoes.

Ball'ing-ma-chine'. (*Cotton Manufacture.*) A machine on which cotton thread is wound into balls.

Fig. 545.



Balling-Machine.

The ball *a* is made on a rotating spindle *b*, or on a paper cap or cover placed thereon, around which a steel rod *c* spins rapidly, carrying the thread and building it up on the spindle. This interior core (cap) forms a support for the ball, and receives on its closed end the ticket, number, and maker's name.

The size of the ball is regulated by the eye; the number to the pound varies from 16 to 600.

The spindles have independent stop-motions, *g*, so that when a thread breaks any one or more may be stopped. The thread comes off a bobbin, and passes through the hollow spindle of the flyer *c*, whose axis of rotation is oblique with that of the spindle *b*, so that the thread is laid on spirally, the spindle continually rotating so that the thread has an advancing or receding coil, according to the direction of motion of the spindle. The gearing by which the parts are driven is sufficiently shown in the cut, and needs no special description. The figure shows one set of parts, but the machine has a long parallel series of ball-winders in a row on a single frame. The upper figures show the ball attached to and detached from its spindle, respectively.

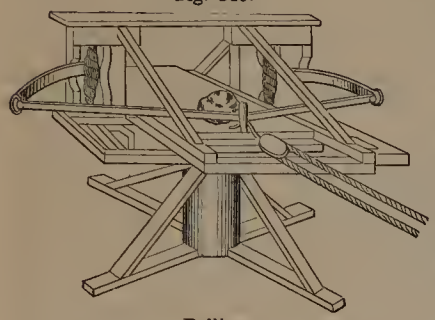
It was invented by M. I. Brunel. When he visited the mills of Strutt, in Derbyshire, about 1805, he said he "observed they had adopted my [his] contrivance for winding cotton into balls."

Ball'ing-tool. (*Metallurgy.*) A tool for aggregating the iron in a puddling-furnace, to fit it for

conveyance to the tilt or squeezer. A *rabble* (Fr. *rable*).

Bal-lis'ta. (*Weapon.*) A machine used anciently for throwing darts or stones.

Fig. 546.



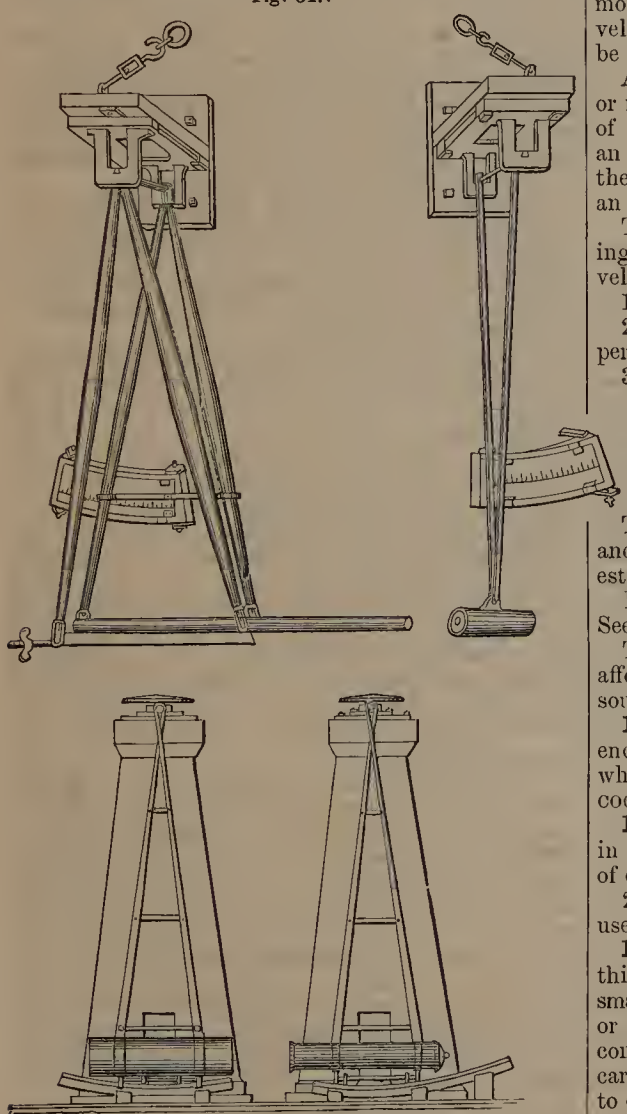
Ballista.

The name is applied to two different machines.

One resembles the catapult in the mode of obtaining the power, and the other is a cross-bow on a large scale, with a tackle to draw the bowstring.

a. The more ancient ballista had a vibrating arm, which was drawn back against the tension of cords made of human hair, horse-hair, or catgut. When drawn back to its full scope, it was suddenly released, and its head came with a violent blow against the ends of the darts arranged on a table above and pointed towards the enemy.

Fig. 547.



Ballistic Pendulum.

b. The other ballista was a cross-bow, arranged upon a standing frame (Fig. 546). The string was retracted by a tackle, and was cast loose by some device, projecting a dart or a stone, as the case might be. The dart or stone lay upon a table, and was adjusted against the string before casting off.

Bal-lis'tic Pen'du-lum. This instrument is designed to determine the velocity of projectiles of cannon and small-arms. It was invented by Robbins about 1760, and described by him in his tract on Gunnery. It has been improved by Hutton and Gregory, in England; Piobert and Morin, in France; and Mordecai, in the United States.

The original instrument consisted of an iron bar suspended by a transverse axis, and having a block of wood strengthened with iron plates to receive the impact of the ball. On being struck, the block swung like a pendulum, and pulled a ribbon through an orifice in the fixed framework. The length of the ribbon withdrawn is considered equal to the chord of the arc of vibration.

The use of the pendulum depends upon the dynamical fact that if a body of small mass impinge with great velocity upon a much larger body at rest, and the two bodies after impact move on together with a velocity which can be easily measured, the masses of the two bodies being given the whole momentum after impact is known; and as this is the momentum of the smaller body before impact, the velocity with which it struck the larger body can be determined.

As now used, the block consists of a cast-iron case or mortar, partially filled with bags of sand or a block of lead. It is suspended by wrought-iron bars from an axis working on knife-edges in V-grooves, and the arc of vibration is measured on a copper arc by an index carrying a vernier.

The arc of vibration being ascertained, the following points must be known, in order to calculate the velocity of the ball on striking: —

1. The respective weights of the ball and pendulum.
2. The distance of the centers of oscillation or percussion from the axis of suspension.
3. The distance of the center of gravity from the axis of suspension.
4. The angular velocity of the pendulum after impact.

The upper figure represents the pendulum for small-arms; the lower one for ordnance.

The gun itself has been swung on a pendulum, and its arc of recoil measured to furnish datum for estimating the force of the discharge.

It is also used to determine the quality of powder. See also EPROUVETTE.

The *Chronoscope* and *Electro-Ballistic* apparatus afford more perfect means of determining the point sought. See CHRONOSCOPE: ELECTRO BALLISTA.

Ball-le'ver. A lever having a ball affixed at one end as a weight, which closes the plug of a cistern when the water has risen sufficiently. See BALL-COCK.

Bal'lon. 1. (*Chemical.*) A large glass receiver in the form of a hollow globe, appertaining to a set of chemical apparatus.

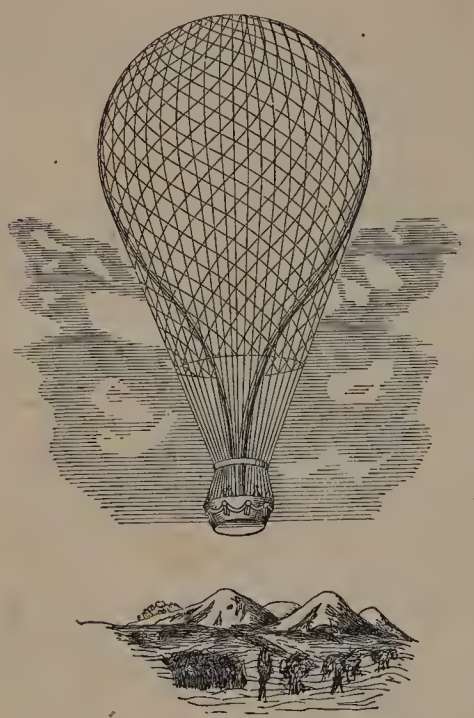
2. (*Nautical.*) A long, brigantine-rigged vessel, used in Siam, and made out of a single trunk.

Bal-loon'. 1. A bag or envelope of silk or other thin textile fabric, around which is a netting of small rope or cord, from which is suspended a car or basket. The balloon is provided with a valve, controlled by a rope within reach of a person in the car, to allow the gas by which the balloon is inflated to escape when it is desired to descend.

Galien, of Avignon, wrote on aërostation in 1575;

but the discovery of hydrogen made by Cavendish, in England, seemed to offer a feasible mode of accomplishing the object, and its use was suggested for that purpose by Dr. Black, in 1767, who ascertained that a light envelope filled with this gas would ascend.

Fig. 548.



Balloon.

The first machine by which an ascent was made into the upper regions of the atmosphere was invented and constructed by the brothers Stephen and Joseph Montgolfier, paper-manufacturers at Annotay, near Lyons, France. After experimenting unsuccessfully with hydrogen-gas, they tried heating the air contained in the balloon by means of a fire in its open mouth, and in June, 1783, a captive balloon was by this means caused to ascend over 2,000 yards. November 21, 1783, Pilatre de Rozier and the Marquis d'Arlandes ascended in a balloon of this kind, reaching a hight of 3,000 feet, and landing nearly six miles from where they arose. December 1 of the same year, MM. Charles and Robert ascended in a balloon inflated with hydrogen-gas, alighting in an hour and three quarters at a spot about 25 miles from Paris, whence they had set out, and attaining an elevation of about 9,700 feet. After this, balloon ascensions, both in France and England, became comparatively frequent. The English Channel was crossed by a balloon; and in making a similar attempt, Pilatre de Rozier and a companion named Romain were killed. They had employed, in conjunction with a hydrogen-balloon, a montgolfiere or fire-balloon below it, and on reaching a considerable hight, the expansion of the gas caused it to flow downward directly upon the fire, inflaming the whole apparatus, which was speedily consumed, precipitating the aëronauts to the earth.

Balloons were introduced into the French armies at an early period during the wars of the Revolution, and were used at the battles of Liege, Fleurus, 1794, and at the sieges of Maintz (Mayence) and Ehrenbreitstein, where they were found particularly useful, as only by such means could operations in the elevated citadel be observed.

"The French armies are attended with a new species of reconnoitering engineers, whose duty it is to do everything relative to the preparation and use of balloons. The person who mounts in the balloon is furnished with paper and pencils of different colors. The marks are made according to a system agreed on beforehand, and the paper, after being marked, is attached to a small rod like an arrow, one end of which is loaded and pointed, so that it strikes in the ground and stands upright."—*Annual Register*, 1794.

Balloons were also employed by the French in the Italian campaign of 1859, at Solferino; and subsequently, during our own civil war, a small corps of balloonists was attached to the Army of the Potomac.

The celebrated French chemist, Gay Lussac, in 1804 reached the hight of 23,040 feet, and carried up with him the necessary means for making scientific observations on the character and properties of the atmosphere at that great hight. This was for many years considered the most remarkable balloon ascent ever made, both in regard to the hight attained and the observations made. The great tenuity of the atmosphere in those elevated regions is said to have affected M. Lussac to such a degree that his system never fully recovered from it. An English aëronaut named Glaisher, it is said, has recently succeeded in reaching the hight of seven miles. He was rendered seriously ill, and was supposed to have burst some blood-vessels.

Charles Green introduced the practice of inflating balloons with ordinary illuminating-gas, making his first ascension with this medium on the day of the coronation of George IV., 1820. Illuminating-gas, besides being much cheaper than hydrogen, has the advantage of being more easily retained within the envelope on account of its greater density.

In 1836, Messrs. Holland, Mason, and Green ascended from London in a balloon of 85,000 feet capacity, taking with them a ton of ballast, a fortnight's provisions, extra clothing, etc. They landed next day in the duchy of Nassau, having made a voyage of about 500 miles.

In June, 1859, Mr. Wise, the well-known American balloonist, ascended from St. Louis and landed in Jefferson County, N. Y., having traveled about 1,150 miles.

Gifford's captive balloon, noted as one of the features of the Paris Exposition of 1867, was 93 feet in diameter, having a capacity of 421,161 cubic feet; weighed 6,000 pounds, the netting and guy-ropes weighing 4,000 pounds additional. It was inflated with pure hydrogen-gas, and the car accommodated twenty-five persons. The rope by which it was held tapered gradually towards its lower end, so that in case of parting it would break near the ground, and not endanger bystanders. It was wound round a drum turned by a steam-engine. The cost of the balloon with its appurtenances, including machinery, was over $45,000.

M. Dupuy de Lorne attempted a few years ago the construction of a navigable balloon of considerable dimensions. In order to maintain its permanence of form, a large balloon was provided with two interior suspended tubes, whose open lower ends communicated with the air; a small interior balloon with valves was placed inside of the larger one, and by its greater or less inflation compressed the tubes more or less, causing the contained gas to rise or fall, so as to cause a uniform tension of the surrounding gas contained in the larger balloon. The longer diameter of this latter was parallel to its axis of motion, and the apparatus was to be propelled by a screw attached to the car and operated by hand-power. The rudder was a triangular sail attached at its

lower edge to a pivoted horizontal yard beneath the car, near its rear, and operated by a rope at each end, extending to the steersman's seat.

The British military authorities assume that a hight of 100 fathoms at a distance of 600 fathoms from an enemy affords an ample field of view. Cameras arranged so as to include the whole horizon, enable the country to be photographed, and telegraph-wires, which can be paid out as fast as the balloon sails, afford communication with the earth or with another balloon.

Experiments made at Tours show that at a hight of 1,000 to 1,200 yards the silk envelope of a balloon could be penetrated by bullets, but that the escape of gas was so slow that with a favorable wind the balloon might reach several miles before falling. At 2,700 yards the best shots failed to penetrate the silk; and this elevation is therefore considered the maximum necessary to insure safety.

The late Prussian and French war, and especially the siege of Paris, gave rise to the most business-like and systematic use of balloons on record. The manufacture is thus described by a newspaper correspondent: —

"The type of the balloons constructed by M. Godard for the Postal Administration is entirely spherical. The proportions are as follows: Diameter, 16 yards; superficies, about 836 square yards; volume, 6,316 cubic yards. The stuff employed is a strong glazed cambric, oiled and varnished. With machinery, forty thicknesses of this cambric are cut out at one time. After this operation these strips are sewed together with a double waxed white thread, and the balloon is repeatedly rubbed with oil, in order to secure its impermeability. A valve in strong wood is set into the upper pole of the balloon; this valve is closed by india-rubber springs. A long cord is attached to this valve, and traverses the lower pole, enabling the aëronaut to regulate the descent of the balloon. A network of tarred twine envelopes the balloon. To the extremity of this net a wooden hoop is adjusted, to sustain the wicker-work basket, which measures about 3 feet in width and 4½ in length. Benches are provided for six persons. Around the basket the sand-bags and dispatch-bags, with three hundred yards of rope, are ranged. This latter provision is intended for throwing out to drag on the ground and diminishing the speed on descending.

"The weight, when filled with ordinary burning-gas is about a ton, comprising six hundred pounds of sand-bags, three persons weighing about 150 pounds each, and 1,000 pounds of dispatches. It requires ten days for the manufacture of each. The cost of each is $1,200."

Carrier-pigeons, also, were much used by the Parisians during the Prussian investment of that city. The flying messengers who have their homes in Paris afforded the means of communicating with the beleaguered city. The use of carrier-pigeons is very ancient. On a temple-wall in Egypt there is a sculpture of the time of Rameses II. (1297 B. C.), representing that monarch proceeding in regal state to assume the crown of Upper and Lower Egypt; and in the procession a priest is seen releasing from a basket four carrier-pigeons, to announce the tidings to distant points.

Ovid relates that Taurosthenes announced to his father in Ægeria, by a pigeon stained purple, that he had obtained the prize at the Olympic games. Brutus used pigeons for communicating with the inhabitants of Modena, during its siege by Marc Antony. When Ptolemais in Syria was invested by the French and Venetians, and was about to surrender, a carrier-pigeon, bearing a message from the Sultan, was captured; the missive containing promises of assistance was removed, and one substituted in which the Sultan expressed no hope of being able to assist them. The surrender was immediate. Pigeons were of great use to the Dutch during the siege of Leyden, so bravely resisted by the Prince of Orange.

The *air-car* is a proposed form of balloon, inflated with gas to secure lightness, and traveling upon wires stretched from pillars upon a definite route. Two pairs of wires are needed, — one pair for each side of the car, — and the upper and under wires of the respective pair run in the grooved peripheries of the car-wheels, which are rotated by a steam-engine on board. The car is cigar-shaped, and has sails to be used with favoring winds. The device for passing the posts is ingenious, but does not differ substantially from the mode of hanging the tracks of caster-wheels for sliding barn-doors.

Signals have been made, and notices, etc., have been distributed, by means of balloons. One was invented by Mr. Shepherd, and used in the Arctic regions in the search for Sir John Franklin. The arrangement consisted of a number of printed packets of oiled silk or paper, upon which directions were printed, stating the latitude and longitude of the exploring ships, where they were going to, and the points at which provisions had been left. These were attached at proper intervals to a long slow-match made of rope dipped in niter; and as the balloon traveled over the country, the match burned gradually away, releasing the packets consecutively, and distributing them over a wide extent of country.

Other devices were also adopted for the same purpose, and are described under SIGNALS.

2. (*Architecture.*) *a.* A mold at the base of a column.

b. A round globe at the top of a pillar.

3. (*Glass.*) A glass receiver of a spherical form.

4. (*Fabric.*) A cylindrical reel on which sized woolen yarn for warp is wound, in order to be dried by rapid revolution in a steam-heated chamber. The yarns are guided by passing between the teeth of a *separator* or *ravel*, which is a toothed instrument like a rake, between whose teeth the yarns pass. This acts as a guide in distributing the yarns over the length of the reel.

The yarns are wound from the balloon on to the *beam* of the loom.

Bal-loon'-jib. (*Nautical.*) A triangular sail, used in a cutter, and hauled up to the topmast-head. Sometimes called a *jib-topsail.*

Bal-loon'-net. (*Fabric.*) A variety of woven lace, in which the weft threads are twisted in a peculiar manner around the warps.

Bal'lot-box. A box in which balls or beans indicating a negative or affirmative, or slips containing the names of candidates for office, are deposited.

Ballot-boxes of the ordinary construction afford no security from fraud, except the honesty and attention to duty of the receivers of ballots.

To guard against the improper placing of tickets in the boxes, they have been made of glass, so that the interior might be open to the inspection of the bystanders, and any surreptitious introduction of tickets therein at once discovered.

The ballot was used in ancient times. It has been suggested that of this character was the *Urim* and *Thummim* spoken of in Exodus xxviii. 30: —

"And thou [Moses] shalt put in the breastplate of judgment the Urim and the Thummim, and they shall be upon Aaron's heart when he goeth in before the Lord: and Aaron shall bear the judgment of the children of Israel upon his heart before the Lord continually."

The conjecture that white and black stones were contained in the pocket behind the breastplate, and, being taken out by the high-priest in consultation, gave affirmative and negative answers respectively, is not supported by the weight of authority. It is rather supposed that images representing respectively *Ur*, light, and *Thom*, perfection, were placed in the breastplate, and indicated by a certain luminosity, or by a failure to respond, an affirmative or a negative answer to the question propounded. Such images, emblematical of truth, were used in ancient Egypt, Greece, Rome, and also in China, as well as among the Hebrews. The image was suspended by a cord, so as to lie over the heart of the judge and the high-priest. Aaron became, in a certain sense, a judge in the matters of conscience or religious polity which were submitted to him. See Adam Clark's commentary on Exodus xxviii. 30.

Ovid, in his "Metamorphoses," lib. xv. verse 41, as rendered by Dryden, says: —

> "A custom was of old, and still remains,
> Which life or death by suffrages ordains:
> *White* stones and *black* within an urn are cast;
> The first *absolve*, but *fate* is in the last."

In the promise to the Church of Philadelphia, also: —

"To him that overcometh will I give . . . . a *white* stone, and in the stone a new name written, which no man knoweth save he that receiveth it." —*Rev.* ii. 17.

White was the emblem of purity, pardon, acceptance, choice, triumph, according to the occasion. By white stones judges indicated their verdict, the people voted their suffrages; and a white stone was to the conqueror in the public games the token of his triumph. Such a *white* stone was inscribed with the name of the conqueror, and entitled him to be maintained for life at the public expense. The Athenian magistrates were chosen by lot. Black and white beans were placed with the names in the urns, and the names drawn out with a white bean were elected.

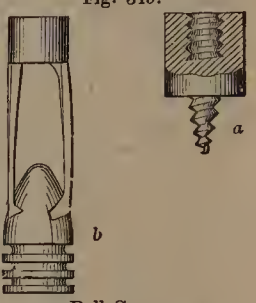
The *tesserœ hospitales* seem to have been particularly referred to in the verse in Revelation. These were a sort of tally: two pieces of stone, bone, wood, or ivory were engraved with some common device, and a piece was kept by each of the two parties contracting a league of mutual friendship and assistance. Such were handed down in the respective families, and guaranteed to the holders all the accommodations and offices of friendship when visiting at the house of the holder of the other portion. Plautus refers to the custom. See Adam Clark in his comments on this passage, and the authors referred to by him.

Secret voting was practiced by the ancient Greeks and modern Venetians, from the latter of whom we derive the term "ballot." A tract, "The Benefit of the Ballot," was published by Marvell in 1693.

Ball-peen Ham'mer. A metal-worker's hammer with a spherical peen.

Ball-screw. An implement for extracting bullets from the barrel of a gun in cases where it would be dangerous or impossible to expel them by firing. It is screwed on to the end of the ramrod, which, being turned, causes the screw-threaded pointed end of the ball-screw to enter the bullet, which is then withdrawn by pulling the ramrod. The common form is shown at *a*, Fig. 549.

Fig. 549.

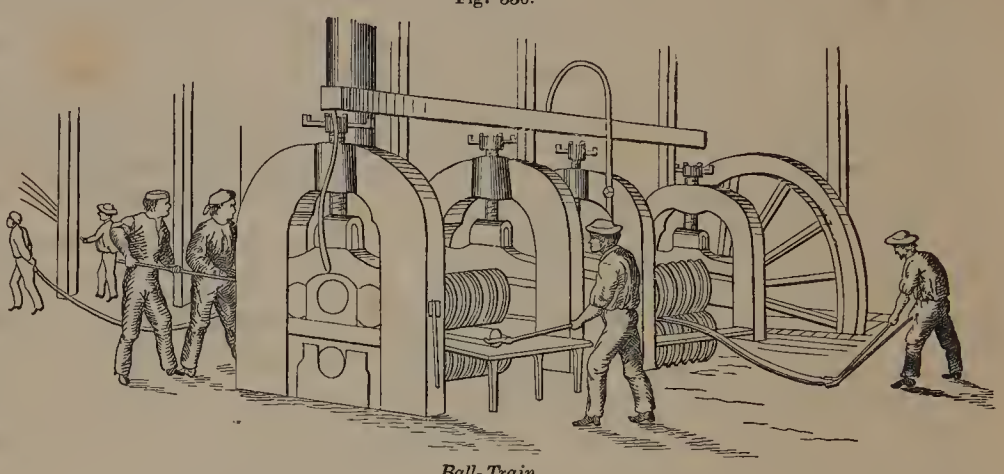


Ball-Screws.

Witzleben's ball-screw, *b*, has two jaws with sharp-edged interior shoulders, constituting a portion of a concave screw-thread, which enters the bullet to prevent it from slipping from the grasp of the jaws.

Ball-train. (*Metal-working.*) A set of rolls for rolling puddler's *balls* into bars. The word *train* signifies that more than one pair is used, the first being *crushing* rolls and the second *finishing*. The result of the action of the two is *bar*-iron. See Rolling-mill.

Fig. 550.

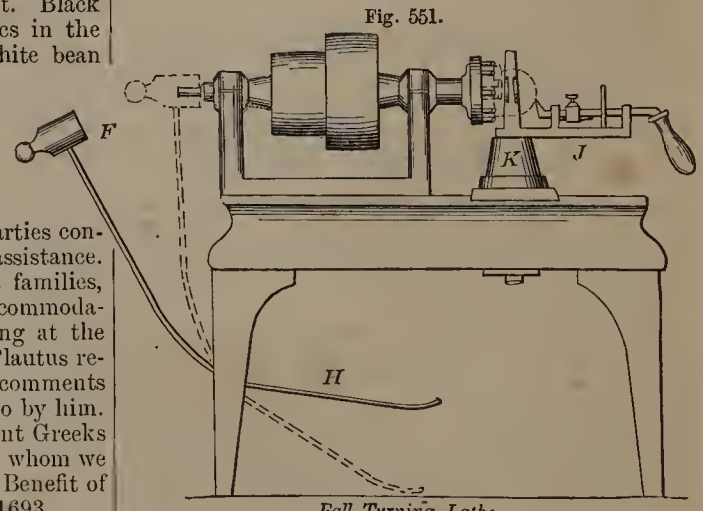


Ball-Train.

Ball-trol'ly. A small iron truck, used in conveying the balls of puddled iron from the puddling-furnace to the tilt-hammer or squeezer.

Ball-turn'ing Lathe. A wood-turner's lathe

Fig. 551.



Ball-Turning Lathe.

for spherical objects, which are held in a chuck on the live-spindle, while the tool has an adjustment in a horizontal arc whose center is coincident with that of the ball.

The block from which the ball is turned is supported at one end only. The chucks are perforated, and the tool is mounted on a swing-rest having a vertical, lateral, and a longitudinal adjustment in its socket, and also a horizontal swinging movement across the axis of the mandrel. *K* is the rest on which the tool-holder *J* swings. The duty of the hammer *H F* is to knock the finished balls out of the chuck.

Ball-valve. A valve of spherical shape, occupying a hollow segmental seat; raised by the passage of the fluid, and descending by gravity. See BACK-PRESSURE VALVE.

Ball-vein. (*Mining.*) A species of iron-ore, found in loose masses of a circular form, containing shining particles.

Bal-mor'al. 1. (*Fabric.*) A striped woolen stuff, deriving its name from Balmoral Castle in Scotland.

2. A sort of ladies' boot, lacing in front.

Bal'ne-um. A vessel filled with some heated substance, as sand or water, in which a thing is placed for treatment that requires a more gentle heat than the naked fire.

Bal'sa. (*Nautical.*) A raft used on the coast of South America, consisting of two inflated seal-skins, which are fastened together at one end to form the prow, and separated abaft by means of a plank. Flexible tubes for inflation are within reach of the navigator, who replenishes the bags as they require. The raft is floored with sticks and matting, and propelled by a double-bladed paddle. It is landed on the shore by the descending breaker, and immediately secured, to prevent its being drawn back by the retreating wave. It carries three passengers besides the navigator.

The CATAMARAN (which see) is often called by this name.

Bal'us-ter. (*Joinery.*) A small pillar supporting a hand-rail, coping, balcony, or terrace. A row of such makes a *balustrade*. They are usually cast hollow, or, when solid, are turned out of stone or wood. The balusters, hand-rails, and base are sometimes made of swaged sheet-metal.

Bal-us-trade'. A hand-rail with its supporting balusters, such as that of a terrace, parapet, balcony, staircase, altar, chancel, or inclosure.

Bal'us-tre. (*Fabric.*) A superior variety of gold cloth, manufactured at Vienna.

Bal-za-rine'. (*Fabric.*) A light mixed material of worsted and cotton for ladies' dresses.

Band. 1. (*Vehicle.*) A circular collar, hoop, or strap, such as that on a nave; a hub-band; an axle-band.

2. (*Architecture.*) *a.* A narrow, flat projecting surface. When narrow, it is a *fillet;* wider, it is a *facia.*

b. The leaden *came* which holds the lozenge-shaped panes in the old-fashioned casement windows.

3. (*Fire-Arms.*) One of the metallic sleeves which bind the barrel to the stock of a musket, etc.

4. (*Bookbinding.*) *a.* One of the cords at the back of a book to which the thread is attached in sewing. Though now a cord, it was formerly a flat band, and hence the name. It usually, in the better forms of binding, makes a raised projection on the back, and in large blank-books is formed by glueing strips of mill-board or leather across the back. In a fine breviary of the fourteenth century, in J. S. Grinnell's collection, it is a thick, rounded, white leather cord secured to beechwood side-boards.

b. The *head-band* serves as a finish to the top and bottom of the sheets, and helps to keep the upper and lower parts of the back in shape when the book is closed.

5. (*Husbandry.*) A bundle of eight or ten stalks of wheat, or other small grain, used to bind a *gavel* of the grain into a sheaf.

Corn-shocks are bound with *stalks*, or with *string*, *linn-bark* (linden or bass), or *rye-straw.*

String or wire is the usual band on the automatic binding apparatus of *reaping and binding* machines, but a bunch of straw out of the sheaf is used in some machines.

6. (*Machinery.*) A flexible connection between pulleys, generally endless, but sometimes attached by its respective ends to reciprocating sectors, or a sector and slide.

Bands may be classed as *belts*, *cords*, or *chains.*

A *belt* is generally flat and thin, and requires a nearly cylindrical pulley.

A *cord* is usually circular in section, and made of catgut, raw-hide, twisted fibers, or wire. It requires a grooved pulley.

A *chain* consists of links or jointed bars, and requires a grooved, notched, or toothed drum.

7. A cincture, strap, or cord, with a means of fastening the ends together, and used to confine the materials of a bale, truss, or bundle. See BALE-TIE.

Band'age. (*Surgical.*) A strip or piece of fabric, cotton, linen, or woolen, or an elastic, knitted, or shirred fabric for wrapping any part of the body. They are applied to dress fractured or lacerated parts, for the compression of bloodvessels and the retention in their natural situations of protruding or displaced parts.

They are *simple* or *compound.*

They are named from their purposes, as —

Uniting, dividing, expelling, retaining, compressing, suspensory, varicose-vein, fracture, catamenial.

They are named from their forms, as —

The *axia*, like an axe.

The *spica*, like an ear of wheat.

The *capistrum*, a split cloth bandage to support the lower jaw.

The *chiastcr*, a cross-shaped bandage for stopping hemorrhages from the temporal artery.

The 4-*tailed* bandage, made from a single split cloth, and also known as Galen's.

The *figure* 8, the *T*, the *letter D*, the *stellated*, or star-shaped, the *circular*, the *spiral*, the *reversed*, the 18-*tailed*, etc.

They are also named from the materials with which they are treated, as starch, dextrine, plaster of paris, etc.

Ban-dan'na. (*Fabric.*) An India silk, printed in one color with white spots or ornaments made by the *resist* or the *discharging* process. *Bandannois.*

In the *resist* process, the spots are printed with a composition to *resist* the dye by which the ground-color is given. Subsequent washing then removes the dye from the spots, the ground-color remaining intact.

In the *discharging* process, the whole handkerchief is dyed of one color, and is then printed in spots with a composition which discharges the dye at those points, so that, in washing, the spots come up white.

One mode of making the white spots in bandanna goods is by causing a solution of chlorine to percolate down through the red cloth in points circumscribed and defined by the pressure of leaden pattern-plates in a hydraulic press, thereby discharging the color in certain places.

Band-coup'ling. A device for uniting the two ends of a band. This may be a pair of ferrules, with

a ball and socket respectively, a hook and eye, strap hinges with a pintle, etc. See BELT-COUPLING.

Band-cut'ting Ma-chine'. (*Agriculture.*) An attachment to a thrashing-machine to cut the bands of the sheaves as they are thrown upon the feed-board. The band being cut, the sheaf is spread out and then pushed head foremost into the *throat*, whence it passes between the *cylinder* and the concave, each of which is toothed.

In England, they prefer to save the straw in a less mangled condition, and feed in sideways; the beaters being bars, not teeth.

Band-driv'er. A tool used in correcting irregularities in the bands of machinery.

Band'ed Col'umn. (*Architecture.*) One having cinctures at intervals.

Ban'de-lore. A toy illustrating the effect of gravity in producing a rotary motion. It consists of two disks, with a deep groove between them, on which is a winding cord. The latter being coiled in the groove, the bandelore is dropped, unwinding the cord; at the end of its stroke, the rotary motion being continued, it rewinds on the cord in the opposite direction, and climbs to nearly its original hight. By a little humoring and motion of the hand, it may be made to rewind the whole length of cord.

Band'ing-plane. (*Wood-working.*) The *banding-plane* is allied to the gages, and is intended for cutting out grooves and inlaying strings and bands in straight and circular works, as in the rounded corners of piano-fortes and similar objects. It bears a general resemblance to the plow, but also has the double-pointed scorer of the grooving-plane. The central plate of the plow is retained, so as to furnish a guide for the central positions of the router and cutter, which are inserted so as to meet at an angle of about 80° between two short portions of the central plate. The whole of the parts entering the groove are compressed within the space of one inch, to pass through curvatures of small radius. A flexible steel fence is attached to the plow by two stays at its ends, while to the central part is attached a screw adjustment to confer upon the fence any required curvature, convex or concave.

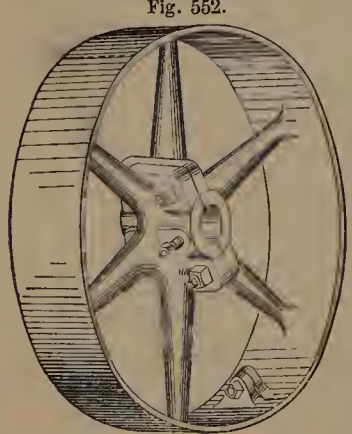
Band'ing-ring. (*Hat-making.*) *Runner-down.* A ring passed over the body of a hat while on the block, so that its edge shall impinge upon the *break* of the band, and form the brim at right angles to the crown in the process of *blocking*.

Band'let. (*Architecture.*) A small fillet or molding.

Ban'dore. (*Music.*) An ancient stringed instrument resembling a lute; referred to in Pepys's "Diary," 1662,—"and music with a bandore for the base."

Band-pul'ley. (*Machinery.*) A flat-faced wheel fixed on a shaft and driven by a band. It is connected either immediately or mediately through other pulleys, with any power which drives machinery.

Fig. 552.



Two-Part Pulley.

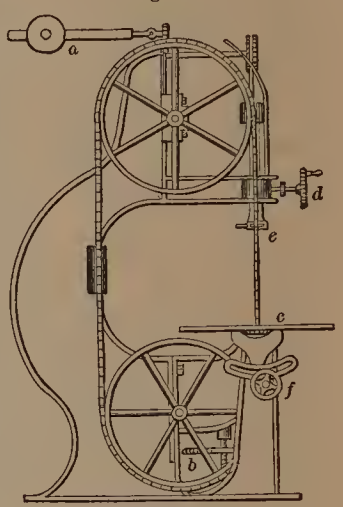
The illustration shows a two-part pulley, having flanges, connected by bolts and nuts, on the hub and rim. A *drum*.

Band'rol. 1. (*Architecture.*) A form of spiral molding in Gothic architecture. *Bandrole.*

2. (*Nautical.*) A little streamer from a masthead.

Band-saw. The band-saw consists of an endless steel belt running over wheels and revolved continuously. It is pliable, so as to conform to the faces of the wheels, and is serrated on one edge. The ends are joined by solder and by neat clamps. Arrangements are made for straining the saw by regulating the relative distance of the wheels; this adjustment also permits the machine to take in saws of different lengths. One advantage of the band-saw over the reciprocating saw is, that there is no lost time in its operation, and no effort required to keep the work to the table, as the action of the saw tends to this result. There is no need of a pump or blower to clear away the sawdust, as it is carried continually downward.

Fig. 553.

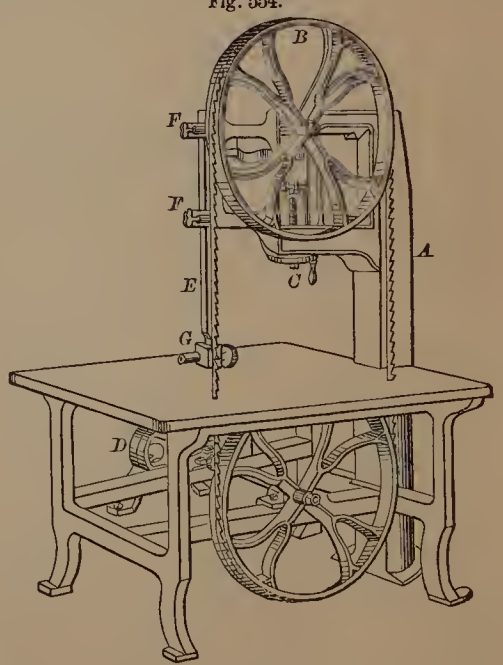


Band-Saw.

In the machine shown there are several adjustments: one by weighted arm *a*, for raising the boxing of the upper wheel, and thus straining the saw; another by wheel *b*, for raising or lowering the table *c*, on which the work is placed; a wheel *d*, by which the saw-guide *e* is raised or lowered, to bring it into the vicinity of the upper surface of the work; a wheel *f*, by which the table is inclined when the work is to be sawed to a level.

In the band-saw represented by Fig. 554, the standard *A* supports a frame, on which is an upright sliding-block and

Fig. 554.



Band-Saw.

arm sustaining a horizontal shaft running in boxes. On this shaft is hung the upper wheel *B*, which, by

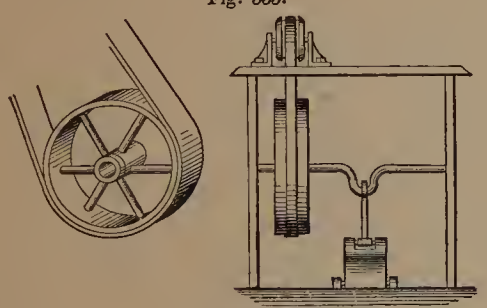
means of the screw and hand-wheel *C*, can be elevated or lowered as the length of the saw demands. The lower portion of the frame, under the table, supports the lower shaft and wheel, which is driven by the pulleys *D*. The two wheels have a flange, against which the back of the saw bears, and the faces of the wheels are covered with vulcanized rubber resting on a bedding of strong cloth. This gives sufficient adhesion to the saw to insure its action as a belt without slipping.

From the front of the upper frame depends a vertical bar *E*, sliding in boxes, to which it may be secured, at any hight required to accommodate the stuff to be sawed, by the thumb-nuts *F*. On the lower end of the bar is a guide *G*, having four sides with recesses of varying depth, to accommodate the various width of different saws. This guide is in two parts, held together by a screw-bolt, and graduated in the distance of their faces by means of the screw-bolt and a four-pronged spring. The saw runs at the rate of 4,000 feet per minute.

In the English practice, the minimum diameter of band-saw pulley is set at 30 inches; but for wider saws the diameter must be increased : thus saws of 2 inches to 3 inches wide ought not to be worked over pulleys of less than 42 inches in diameter, and for a blade 6 inches wide the pulleys should be 70 to 80 inches.

Band-wheel. (*Machinery.*) This is sometimes termed a pulley, — a term which has, however, particular relation to tackle. The band-wheel has a nearly flat or a grooved face, according to the shape

Fig. 555.



Band-Wheel.

of the band. If it be flat, the face of the pulley is slightly rounded so as to keep the band from running off. If the band be round, the pulley is grooved to retain it, as in the wheel on the mandrel of the common foot-lathe.

Ban'gle. 1. (*Nautical.*) The hoop of a spar.

2. An ornamental ring, worn upon the arms or ankles in Asia and Africa.

Ban'gra. (*Fabric.*) A coarse Indian cloth, made from the fiber of a gigantic stinging-nettle.

Ban'is-ter. 1. (*Architecture.*) Originally, *baluster*. One of the vertical supports of a hand-rail on a balcony or stairs. Also the *hand-rail* itself. "He ascended, holding on by the banisters."

The baluster has a curved outline, and is frequently provided with a base and cap, or ornamental moldings, while banisters may be plain or square.

2. A broad central upright in a chair-back.

Ban'jo. 1. (*Music.*) A five-stringed musical instrument having a head and neck like a guitar, and a body like a tambourine, consisting of a circular frame over which sheepskin or parchment is stretched; it is of almost universal use among the negroes in the Southern States. Its simplicity, and the ease with which it is made and played, no doubt made it such a general favorite among them. Its thrumming sound has a near resemblance to the *tam-tam* of the Africans and the Orient. The latter is a lizard's skin stretched over a gourd; a tambourine, a sort of drum.

The guitar appears in the sculptures of ancient Egypt and Nimroud, and is much used in modern Oriental countries.

In the *kermanjeh*, or Syrian fiddle, the bridge-piece is supported upon the parchment cover of the body.

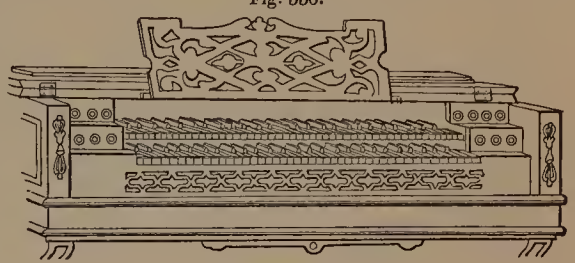
2. (*Nautical.*) The brass frame in which a screw-propeller is hung for hoisting.

Bank. 1. (*Cotton, etc.*) A creel for holding rows of bobbins ; a *copping-plate* or *copping-rail*.

2. (*Glass.*) The floor of a glass-melting furnace.

3. (*Music.*) A bench of keys of a stringed or wind instrument. Generally applied to organs which have

Fig. 556.



Double Bank.

several key-boards or banks of keys belonging to the different aggregated organs, which combine to form an instrument of great power.

Such instruments are made up of a *choir* organ, *great* organ, and *swell*, to which may be added a *pedal* organ or *foot-keys*, for acting on the larger pipes. Each of these is adapted for particular effects : the *choir organ* for light and solo parts ; the *great organ* for powerful effects ; the *swell* for *crescendo* and *diminuendo* effects. Each has its key-board, one rising above another in front of the performer, and all within convenient reach.

The keys are thus arranged in three *banks* or tiers in the case described, and the keys of one bank, by a suitable device which may be thrown in or out of action as desired, may be *coupled* to the corresponding keys of another bank, so that the pressure on one is communicated to the other, to give the combined effect with a single manipulation.

Church reed-organs on a smaller scale and of portable size are frequently double-banked, the keys of one bank being concerned in the use of a powerful set of stops, and those of the other with other stops of a more mellow and moderate tone. See STOP ; ORGAN.

The organ of S. Alessandro in Colonna, at Bergamo, built by Serassi in 1782, has four banks of keys and 100 stops. The first and second bank belong to the great organ and choir organ ; the third is connected by mechanism, which passes underground to a distance of 115 feet, to a third great organ in another part of the church opposite the first.

The *claviers* of the Continental European churches are frequently fixed in a detached upright console, at which the organist sits facing the altar and congregation, so as to be able to watch the service and introduce the music at the proper times.

4. (*Mining.*) The face of the coal at which miners are working.

5. *Nautical.*) *a*. One tier of oars in a *galley*. When a galley is propelled by rowers seated on two or more tiers of benches, one above another, the galley is said to be *double-banked*, *triple-banked*, etc.

b. A seat for rowers in a galley ; a *thwart*.

Common galleys have 25 banks on a side, one oar to a bank and four men to an oar. *Galeasses* have 32 banks on a side, and six or seven rowers to a bank.

c. An oar is *single-banked* when it is rowed by one man. An oar is *double-banked* when pulled by two men, as the captain's barge. This term is also sometimes applied when separate oars are pulled by two men sitting on the same seat.

6. (*Printing.*) *a.* A wooden table for holding the paper to be fed to the hand-press. The paper is slipped off the *bank* on to a slanting board called the *horse*, from whence it is taken sheet by sheet.

b. The support of the moving carriage of a printing-press.

Bank-a-larm' Tel'e-graph. An apparatus for conveying to a director's room, or police, notice of surreptitious entering of the bank, or for conveying regular notices of "All 's well."

Bank'er. 1. (*Bricklaying.*) A bench used by bricklayers in dressing bricks to a shape suitable for skew or gaged work, domes, niches, etc. On one end of it is a grit-stone called a *rubbing-stone*, and on other portions is room for operating upon the bricks with the *tin-saw*, by which *kerfs* are made in the bricks to the depth to which they are to be hewn. An axe is used for dressing off the surface.

2. (*Fine Arts.*) A modeler's bench. It is about 30 inches high, and has a top 30 inches square. On this is a circular platform which turns on wheels, so that the figure can be revolved to expose any portion to the light.

3. (*Nautical.*) A vessel in the deep-sea cod-fishery on the Newfoundland Banks.

4. A seat cushion.

Bank'ing. 1. (*Engraving.*) Raising a wall of wax around an etching on a plate, to form an embankment to hold the acid used in *biting-in*. See ETCHING.

2. (*Steam-Engineering.*) Banking up the fires consists in raking them to the bridge of the furnace, and then smothering them with cinders and small coal, the draft being at the same time checked. By this means the fires are kept in a state of languid combustion, but are ready to burn up briskly again when steam is wanted at short notice, the red-hot mass being then broken up, raked forward, and the draft readmitted.

The fire is said to be *drawn forward* when fuel is added and the draft turned on.

Bank-note. A promissory note issued by a bank, and intended to circulate as currency.

Chinese paper money was issued about A. D. 1100. "Blest paper credit," as Byron says. Genghis Khan issued paper money, but all his power could not give it a purchasing value above fifty per cent of its face.

In "The Book of the Balance of Wisdom," by Al-Khâzinî, a learned Arab of the twelfth century, occurs the remark that, in the first division of his book, are "added chapters on exchange and the mint, in connection with the mode of proceeding, in general, as to things salable and *legal-tenders*."

The Bank of England commenced business at Grono's Hall, Poultry, London, in 1695. No notes were issued under £ 20.

Notes of £ 5 were issued in 1793.

Bank-note En-grav'ing. The chief object in the manufacture of bank-notes is to render forgery impossible, or at least easy of detection. This is sought to be effected by peculiarity of paper, design, and printing; or by a combination of these means, as is done in the Bank of England and other banks. The mechanical design, however, has chiefly been relied on for security. It has been the constant aim to make the impression such as to render the genuine note readily distinguishable by the public for its high art, and to the bank officials by secret peculiarities in its execution. Until about 1837, copper-plate printing was the only process in use for bank-notes. In that year, however, PERKINS effected his valuable improvements in practical engraving. In 1855, electrotype printing was introduced in the Bank of England by Mr. Smee, and since that time the notes have been produced by surface-printing by the electrotype.

The design is engraved in relief on separate pieces of metal, — copper, brass, and steel. From the aggregated pieces a matrix is obtained by electro-deposition, and from this a plate is obtained by the same means. When backed and mounted the plate is used for surface-printing.

In America and in the Bank of Ireland, the plates are prepared according to PERKINS's method. The separate designs forming the complete bank-note are first engraved by hand on separate steel blocks, which are afterwards hardened, and are preserved as permanent patterns not to be printed from. These engravings are transferred to the steel rollers under heavy pressure, the rollers being afterwards hardened and used as dies to impress the engraving upon the printing-plates. The engraved plates for printing the bank-note are made of soft steel, and are never hardened after being engraved. Being of large size, — 20 inches by 16 inches, — they would most probably lose their flatness in hardening. Another reason for not hardening the plates lies in the fact that, when worn, the soft plates are easily repaired by re-application of the rollers thereto.

The printing-plate, when receiving its first impression from the master roller or die, is fixed upon the table of a strong press, from which a pressure of 10,000 pounds can be obtained, the pressure being regulated as required by means of a weighted lever. The position of two register-points in the plate is accurately noted by means of a micrometer microscope, and registered in a book kept for the purpose. The master-roller is then passed over the plate by the machine under the heavy pressure, being very steadily guided by a special parallel-motion arrangement. The table is provided with complete adjustments of peculiar delicacy, and the pressure of the engraving roller upon the plate is not produced by the roller descending upon the plate, but by the table being raised up to the roller.

When a plate requires renewing, it is again fixed upon the table in the same position as before by means of the micrometer microscope and the register of its position; the roller being passed over it deepens those parts of the impression which the continuous printing has worn away.

Bank-pro-tec'tor. (*Hydraulic Engineering.*) To prevent the washing away of banks by the action of waves or currents. See FASCINE; GROIN; SHEET-PILING; CRIB; PITCHING; RETAINING-WALL; DIKE; SEA-WALL, etc.

Ban'ner. A small fringed flag, depending from its staff by cords attached to the ends of a cross-piece.

Ban-quette'. 1. (*Fortification.*) A raised bank at the foot of the interior slope of a parapet, on which the soldier stands to deliver his fire. See INTRENCHMENT; ABATTIS.

A banquette is also found in some fortifications at the foot of the counterscarp, to enable defenders to fire over the crest of the glacis.

2. (*Civil Engineering.*) *a.* A raised footway adjoining the parapet of a bridge.

b. A ledge on the face of a cutting.

Ban'tam-work. Painted or carved work, resembling that of Japan, only more gaudy.

Bap'ta-te'rium. A back-mill or fulling-mill.

Bap'tis-ter-y. (*Architecture.*) A building appertaining to a cathedral or church, or a portion of the church itself, in which the ceremony of baptism is performed. If a separate building, the baptistery was, in the earlier ages, either hexagonal or octagonal in plan; afterwards they were made polygonal, or even circular.

When within the church, it is merely the inclosure containing the font, as in English churches of the present day.

Bar. A word of various signification in different branches of the practical arts; as

1. (*Hydraulic Engineering.*) *a.* A sedimentary deposit in a river, or at the embouchure of one.

b. A boom of logs preventing navigation.

2. (*Nautical.*) *a.* A lever used in a capstan. They are inserted like spokes in the capstan-head, and serve to rotate it. The analogous levers in a windlass are *handspikes*.

b. A flat iron rod securing a hatch.

c. A piece of iron or wood to secure a gun-port.

3. (*Machinery.*) *a.* A *bar-lathe* is one whose shear is a single piece, frequently triangular in section.

b. A large arbor supported between the centers of a lathe, and carrying the cutter by which a cylinder or gun is bored out. A *boring-bar*. See CYLINDER-BORER; BORING-MACHINE.

4. (*Mining.*) *a.* A drilling or tamping rod.

b. A vein running across a lode.

5. (*Weaving, etc.*) A *driving-bar* is a movable operating part in a lace-machine.

A *bar-loom* is a small-ware loom.

6. (*Printing.*) *a.* The portion connected with the handle of a hand printing-press, and acting to depress the platen.

b. The middle, long cross-piece of a printer's chase.

7. (*Husbandry.*) Shifting rails which are removable from their mortises in the posts are termed bars, and the complete device is a sort of substitute for a field-gate.

8. (*Saddlery.*) *a.* One of the side pieces uniting the pommel and cantle of a saddle-tree.

b. The mouth-piece of a bridle-bit which connects the two checks.

9. (*Furnace.*) *Grate-bars* or *fire-bars* support the fuel, and rest on *bearers*.

10. The *crowbar* is an iron lever used in many ways.

11. (*Carpentry.*) *a.* A horizontal piece of timber or metal connecting other portions of a framework.

b. A crosswise piece of wood or metal held by staples or bolts, and forming an inside fastening for door or shutter.

c. One of the thin strips of wood forming the divisions of a sash.

12. (*Vehicles.*) The piece to which the traces are attached; a *splinter-bar* is permanently attached to the carriage; an *equalizing-bar*, or *evener*, is otherwise known as a *double-tree*, swings on a pivot, and has a *single-tree* or *whiffle-tree* at each end.

Bar'an-gay. (*Nautical.*) An Indian vessel propelled by oars.

Bar'ba-can. (*Fortification.*) *a.* An advanced work to defend a bridge, gate, or approach. Otherwise, *barbican*.

b. An embrasure.

c. A channel or scupper in a parapet to discharge water.

Barb-bolt. (*Machinery.*) One having jagged edges to prevent retraction after driving; a *rag-bolt*.

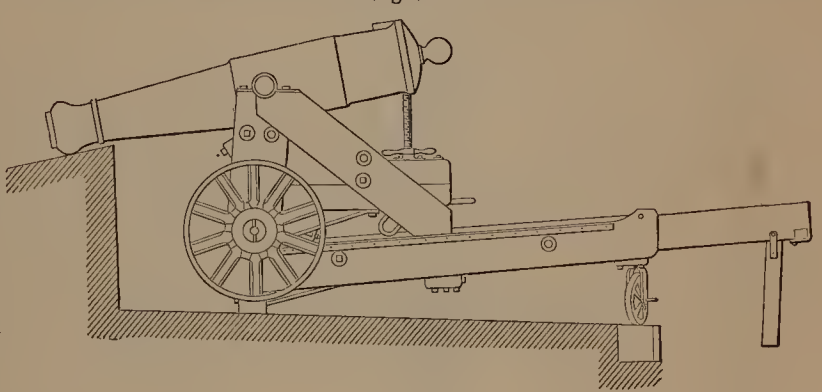
Bar'be-cue. In the Cingalese treatment of coffee-berries this is the dry floor on which coffee is sun-dried after the pulp is grated therefrom, and the beans in their parchment envelope have undergone a preliminary soaking. It is circular, of stone, with a white plaster surface, sloping away from the center, and smooth as glass. The coffee is sunned upon it for four days without removing the sac, in which a pair of berries are inclosed, the object being to dry it previous to being dispatched to Kandy.

Bar'ber's Chair. One adapted for the special uses of a barber, with a vertically adjustable head-rest, arms, an elevated footstool. In some barber's chairs there are drawers and shelves for the apparatus and appliances.

Bar-bette'-gun. (*Fortification.*) When a cannon is mounted so as to be fired over the crest of the parapet instead of through an embrasure, it is said to be mounted *en barbette*.

In field-works, a mound of earth is thrown up against the interior slope of the work; its upper surface is nearly level, and of such a hight as to allow the gun, mounted on its carriage, to be fired over the crest; a slope, termed a *ramp*, is made at the rear of the barbette, and descends to the *terre-plein*.

Fig. 557.



Barbette.

The parapet may be on the summit of a fort which has lower tiers of guns in casemate, or it may be a mere earthwork. The term *barbette* is from the French, as are almost all our military terms, and it means a work adapted to be fired over, and yields a certain amount of protection to the gunners, the piece, and the ammunition. The carriage is adapted to be run "in and out of battery" on a *chassis*, and the latter has a circular motion on a pintle, to enable the guns to be trained horizontally.

When the pintle is arranged at front, as shown in the figure, the amount of this circular motion is limited; on a center-pintle carriage the gun may be directed toward any point of the horizon. Such a gun is called a *pivot-gun*.

Bar'bi-can. See BARBACAN.

Bar'ca. (*Nautical.*) A Portuguese two-masted vessel. Used also in the Mediterranean. *Barcon*.

Bar-cut'ter. (*Metal-working.*) A shearing-machine which cuts metallic bars into lengths.

Fig. 553.

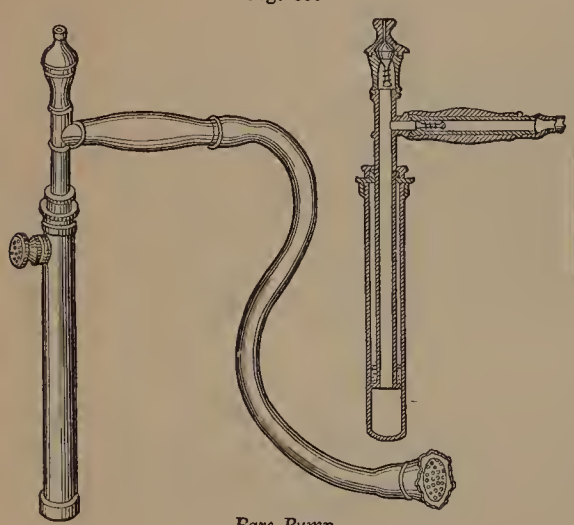
Bar-Cutter.

The purposes are various, — for cutting bars into pieces for fagoting and reheating, for nail-plates, etc.

Ba-rege'. (*Fabric.*) A lady's thin dress-goods, all wool, plain or printed. So called from *Bareges*, a town in the Pyrenees.

Bare-pump. (*Hydraulics.*) A portable suction-pump for drawing liquor from casks. Such are used in vinegar works, in wine and beer cellars, for

Fig. 559



Bare-Pump.

sampling, etc. In the illustration the piston is hollow, and carries a spring-valve, which closes as the piston rises, and opens to allow the air to escape as the piston descends.

Bar-frame. (*Furnace.*) The frame which supports the ends of the grate-bars.

Barge. (*Nautical.*) *a.* A vessel or boat of state or pleasure; as the *Bucentaur*, the state galley of Venice; Cleopatra's galley; the Lord Mayor of London's barge, etc.

b. A man-of-war's boat next in size to the launch. The boat for the special use of the commander of a fleet or squadron is also called a barge. It is 30 to 32 feet long, has a beam equal to .29 to .25 of its length, is *carvel*-built, and carries from 10 to 12 oars.

c. A large boat for the conveyance of goods and passengers. In the United States they are frequently of 600 to 800 tons burden, have two upper decks, and are destitute of motive-power, being towed by steamboats.

Barge-board. (*Carpentry.*) A board beneath the gable, hiding the horizontal timbers. It is perforated, scalloped, or crenated, to give it a light and ornamental appearance.

Fig. 560

Barge-Board.

Barge-coup'le. (*Carpentry.*) A beam mortised into another to strengthen the building.

Barge-course. (*Architecture.*) *a.* That portion of the shingling or slating of a roof which projects over the gable-end.

b. A coping course of bricks laid edgewise and transversely on a wall.

Ba'ri. The portion of a roofing-slate showing the gage, and on which the water falls.

Bar'i-tone. (*Music.*) A kind of bass-viol.

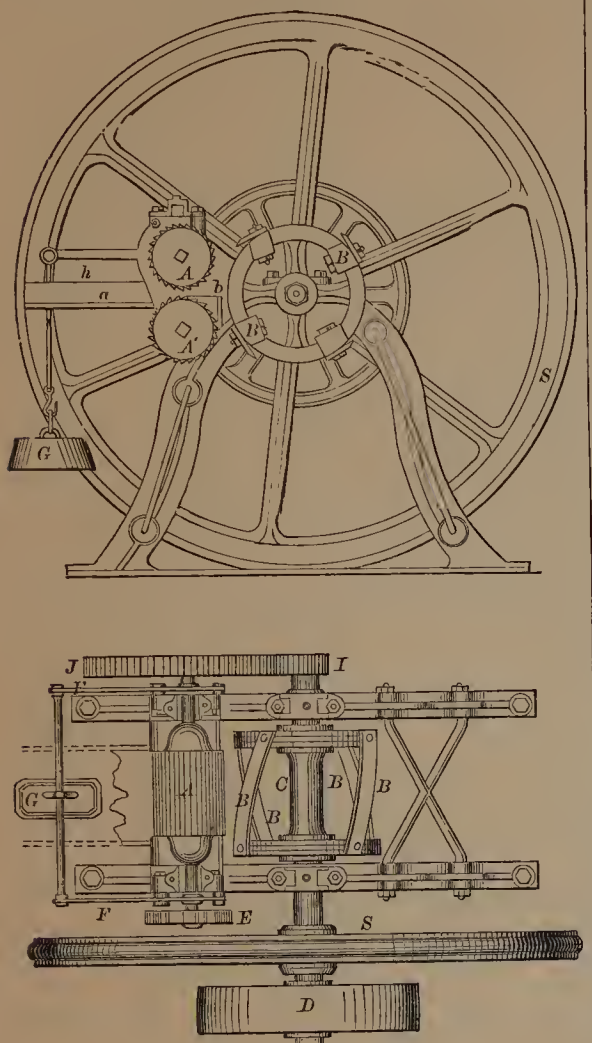
Ba'ri-um. A metal, the base of heavy spar (sulphate of baryta), discovered by Davy. It is of a grayish or yellowish hue, has only been procured in very minute quantities, and is rapidly converted into an oxide by the action of either air or water. It has never been applied to any practical use in the arts. Equivalent, 68.5; symbol, Ba. An oxide of barium, when reduced to a white powder, is used to adulterate white lead, and also as a cosmetic, — both very bad practices; one injures the paint, and the other the complexion.

Bark-cut'ting Ma-chine'. Bark is reduced to a state of minute division to enable the water to dissolve out the tannin more readily and perfectly.

FARCOT's *Bark-cutting Machine* (French) is shown in side elevation and plan. *A A'* are two fluted cylinders which supply the bark previously spread upon the table *a* to the cutting-apparatus. *h* is a raised ledge to keep the bark on the table. The cutting apparatus consists of two parallel circles fixed upon a common axis *C*, having steel plates or knives *B B*, which are disposed in a spiral form. The shaft *C* and fly-wheel *S* are driven by a band on the drum *D*. A pinion at the other end of the shaft *C* carries a pinion *I*, which acts upon a wheel *J* on the axis of the fluted cylinder *A*, which is communicated by wheel *E* to cylinder *A'*. By the levers *F F* and weight *G*, the two cylinders *A A'* are regulated to any required proximity. Inside the fluted cylinders is a longitudinal piece of steel *b*, which acts as a support for the bark as it is cut by the knives *B B*, its edge forming, as it were, one bar of the cutting-shears.

The cylinder which carries the cutting-knives makes about 130 revolutions per minute, and the quantity of bark cut is about 1,600 pounds per hour.

Fig. 561.

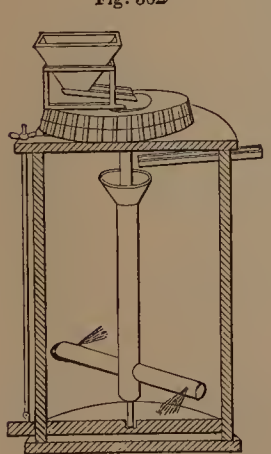


Bark-Cutting Machine.

Bark'er's Mill. (*Hydraulic.*) The Barker mill has attained celebrity rather as an interesting illustration of the principle of reaction or recoil than as a practically useful machine. It, however, has the essential features of the famous turbines and other reaction wheels.

It consists of a vertical tube having an open funnel at top, and branching at its lower end into two horizontal radial tubes. Each of these horizontal arms has a round hole on one side of it, the two holes being opposite to each other; and the vertical tube, being mounted on a spindle or axis, is kept full of water, flowing into the funnel at the top.

Fig. 562



Barker's Mill.

The issue of water from the holes on opposite sides of the horizontal arms causes the machine to revolve rapidly on its axis with a velocity nearly equal to that of the effluent water, and with a force proportionate to the hydrostatic pressure due to the vertical column and to the area of the apertures; for there is no solid surface at the apertures to receive the lateral pressure which acts with full force on the opposite side of the arm.

According to Dr. Robinson, this unbalanced pressure is equal to the weight of a column having the orifice for its base, and double the depth of the water in the trunk for its hight.

The machine has, for one hundred years, been a favorite subject with writers on dynamics, and has been modified by mechanicians.

De la Cour (1777) proposed to bring down a pipe from an elevated reservoir, and, recurving its lower end upwardly, introduce the water into a short pipe with ten arms which revolved in a horizontal plane in the manner described.

The revolving arms may be mounted on a horizontal axis so as to obtain the requisite direction of motion without intermediate gearing.

In 1841, Whitclaw obtained a patent for an improvement, in which the horizontal arms assumed the form of the letter S. In this machine the water is discharged tangentially, the capacity of the arms being greater as they approach the center of rotation, so as to obtain a quantity of water at every section of the arm inversely proportionate to its velocity at that section. The transverse sections of the arms are everywhere parallelograms of equal depth, but of width decreasing from the central vertical pipe to the jet at the outer extremity of the arm.

A small machine of this description was constructed, having a fall of 10 feet, the diameter of the circle described by the ends of the arms being 15 inches, and the aperture of each jet 2.4 inches in depth by .6 inches in width, the area of each orifice being 1.44 inches, the water expended was 38 cubic feet, the revolutions 387 per minute, and the effect equal to 73.6 per cent of the power employed.

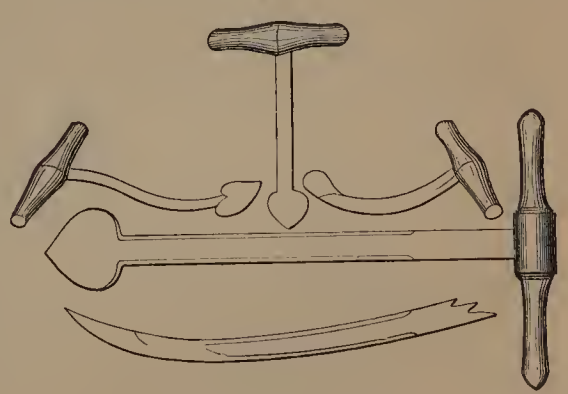
Bark'ing. 1. Coloring sails, nets, cordage, etc., by an infusion or decoction of bark.

2. Stripping trees of bark for cork, dye, tanning material, or medicine.

Bark'ing-axe. An axe of proportions and shape adapted for barking trees.

Bark'ing-tools. For removing the bark of trees for tanning purposes. Besides the axe or hatchet for slitting the bark longitudinally, and for cutting

Fig. 563.



Peeling-Irons.

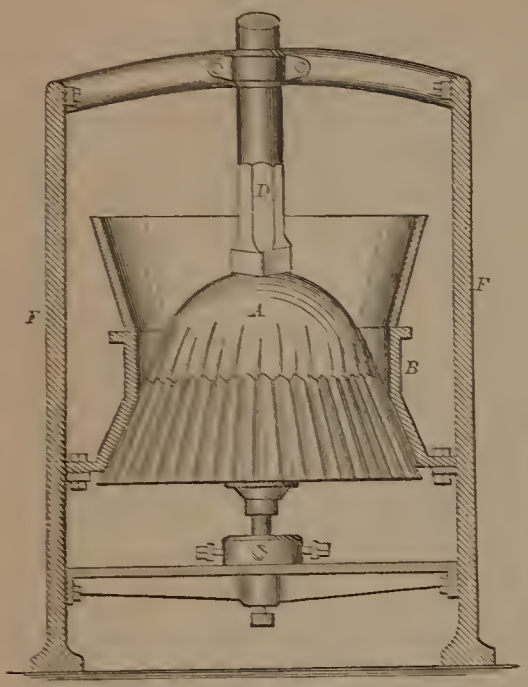
incisions around the trunk, which enable it to be removed in lengths, the barker requires *peeling-irons*, which are thrust beneath the bark to loosen it. The operation is performed in spring, when the sap is abundant between the bark and the wood.

Rossing is not the exact equivalent of barking, as the former is a grinding or cutting action (usually),

the latter a *peeling*. See Loudon's "Encyclopedia of Agriculture."

Bark-grind'ing Mill. WELDON'S *Bark-Mill*, 1797, has a conical iron drum *A* provided with teeth, and rotating in a casing *B*, the upper part of which forms a flaring hopper. The casing and its contained grinder are supported by a framing *F*, and motion is given to the cone by a belt running upon a drum on

Fig. 564.



Bark-Grinding Mill.

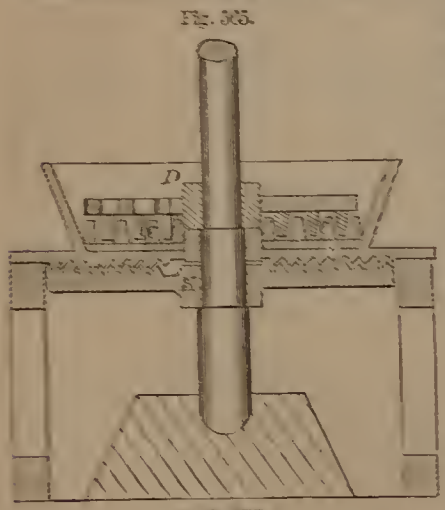
the upper end of the shaft *D*, whose lower end is supported in a step or ink. A screw below the step affords means for adjustment of the cone in the casing, the faces of the two being toothed, so as to effectually rasp the bark as it passes between their adjacent surfaces.

Bark'ing-mal'let. A short-handled mallet of hard wood. The face is three inches square, and the other end is sharpened to a *peen* or wedge.

Iron is a preferable material, and the same tool may be used for *ringing* the tree and splitting the envelope of bark longitudinally, so that it may be removed by the *peeling-iron*.

Bark-mill. In Fig. 565 the bark is broken between the breaker *D* and teeth *c*, thence passing between the rough-bottom surface of the hopper and the rotating disk *E*, by which it is reduced to powder.

Fig. 565.



Bark-Mill.

Bark-om'e-ter. A hydrometer so graduated as to determine the strength of ooze according to a given scale of proportions, water being zero.

Bark Pa'per. Throughout Southeastern Asia and Oceanica the *Broussonesia papyrifera*, or paper mulberry, is a common tree, and its bark is capable, by soaking and beating, of assuming the appearance of fine linen. It may be bleached, dyed, and printed, and is a common material for dress in the islands of Oceanica. In Java and Sumatra it is the common material for writing upon. When solidified and burnished, it resembles parchment. Manuscripts in European museums attest its quality. The same bark made into a pulp is used in China and Japan for making paper.

The processes adopted with bamboo and the mulberry-bark are substantially similar after the reduction of the raw material into a pulpy condition. The Chinese processes are as follows: —

The paper-stuff being rinsed with water alone, or with water in which rice has been boiled, is brought to the state of pulp, and then transferred to a vat having on each side of it a drying-stove in the form of the ridge of a house; that is, consisting of two sloping sides touching at top. These sides are covered externally with a smooth coating of stucco, and a flue passes through the brickwork, so as to keep the whole of each side equally and moderately warm. A vat and a stove are placed alternately in the manufactory, so that there are two sides of two different stoves adjacent to each vat. The workman dips his mold, which consists of a sieve-like bottom and a movable raised frame surrounding it, into the vat, and then raises it out again; the water runs off through the perforations in the bottom, and the pulpy paper-stuff remains on its surface; the frame is then removed, and the sieve is pressed bottom upward against the side of one of the stoves, so as to make the sheet of paper adhere to its surface and allow the sieve to be withdrawn. The water speedily evaporates by the warmth of the stove, and before the paper is quite dry it is brushed over on its outer surface with a size made of rice; this also soon dries, and the paper is then stripped off in a finished state, having one smooth surface, it being the practice of the Chinese to write only on one side of the paper. While this is taking place, the molder has made another sheet, and pressed it against the side of the other stove, where it undergoes the operation of sizing and drying, as the other had done. If sheets of very large dimensions are to be made, the mold is suspended by a tackle and is managed by two men; but in other respects the process is the same as that just described.

Exceedingly beautiful paper is produced by this very simple method. Paper is made in India in much the same way and with nearly the same materials; but in the provinces north of the Ganges, and in Nepal, the common material is the bark of a species of *Daphne* (laurel), which, like that of the paper-mulberry, consists almost wholly of fiber.

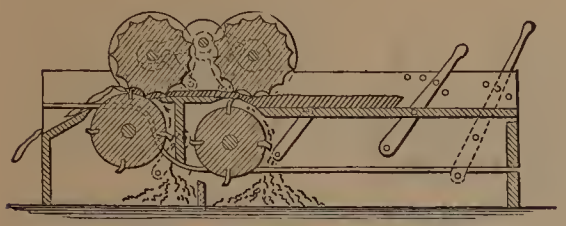
Another mode adopted by the Chinese is to dip out the pulp in a mold made of strips of bulrushes in a frame. The sheets from the frames are piled on a table with intervening strips of reed, by which they may afterwards be lifted leaf by leaf. Each heap is pressed by boards and weights to express the water, and the following day, the leaves, being lifted singly, are laid on a plank in the sunshine to dry.

Bark-pit. (*Tanning.*) A pit partly filled with bark and water, in which hides are steeped in the process of tanning.

Bark-plan'ing Ma-chine'. A machine in which the layer of bark is subjected to the action of consecutive cutters, to separate the inner and outer layers.

The bark is passed beneath the rollers with the rough side uppermost, and the first cutter removes the in-

Fig. 566.

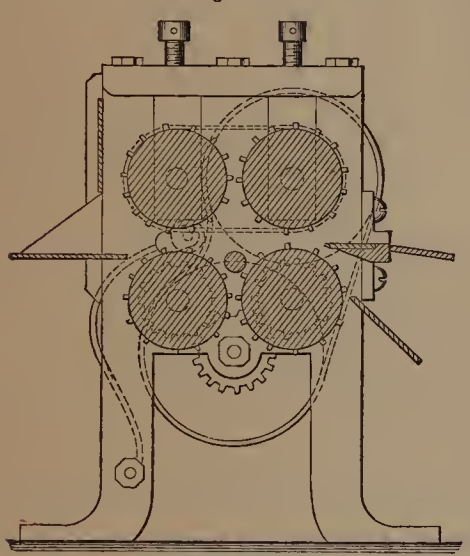


Bark-Planing Machine.

most bark, the second the inner portion of the outer bark, the extreme outer portion of the bark being discharged from the machine down the incline to the left. The dust removed by the respective cutters falls into separate receptacles.

Bark-ross'ing Ma-chine'. A machine for removing the *ross*, — that is, the rough, scaly portion from the outside of bark. The ross has a lesser proportion of tannin, and by its removal a steep of greater strength may be obtained and vat-room saved.

Fig. 567.



Bark-Rossing Machine.

In the example (Fig. 567), the machine consists of two pairs of toothed rollers which feed in the bark and thrust it against the stationary knife, which divides the *ross* from the liber, and the separated portions slide down different inclines to special receptacles.

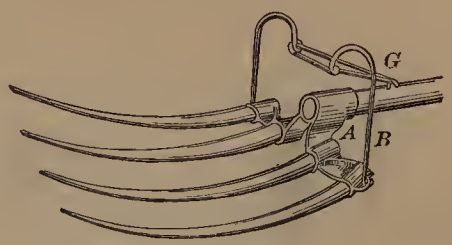
Bark-stove. (*Horticulture.*) A bed of spent bark and soil, heated by flues or steam-pipes, aided by a slow fermentation of its materials. It is used to make a bottom heat for plants growing in pots which are plunged therein.

Bar-lathe. (*Turning.*) A lathe whose beam or shear consists of a single bar on which the puppets or stocks and the *rest* are arranged. The bar is generally of a triangular shape in cross section, one flat side downward.

Bar'ley-chump'er. (*Agriculture.*) A machine for breaking the awn from the grain. (Prov. English.) A *hummeling-machine.*

Bar'ley-fork. (*Agriculture.*) A fork specially adapted for gathering up the unbound gavels of barley or other grain, the stalks of which are too short to be readily made into sheaves. For this purpose it is provided with an upright arrangement, as *B*, at the base of the tines. In the example shown, the

Fig. 568.



Barley-Fork.

tines and handle are attached to the metallic socket-head *A*, the whole being braced and supported by the bow *B* and brace *G*.

Bar'ley-hul'ler. (*Milling.*) A machine for taking the hull or cuticle from the grain of barley, making *pot-barley* or *pearl-barley*. The former has merely lost the cuticle, the latter has had a further amount of its substance removed by prolonging the process for double the length of time. The process is analogous to that of *hominy-making*. See HULLING-MACHINE ; HOMINY-MACHINE.

Bar'ley-mill. (*Milling.*) A mill for decorticating barley ; bringing it to the condition known as *pearl*-barley, the husk or the rind of the seed being removed. There are several ways of accomplishing this : 1. By the usual English barley-mill, — a stone roughened on its circumference, and revolving in a metallic casing with holes like a grater pointing inward and upward.

2. By so regulating the distance between the ordinary runner and the bed-stone that the grain is not mashed, but merely the bran rubbed off.

Bar-loom. (*Weaving.*) A loom for weaving ribbons.

Barm. (*Brewing.*) The foam or froth rising from malt liquors ; yeast.

Bar-mil'li-ans. (*Fabric.*) An old name for a kind of fustian goods largely exported from England.

Bar'na-cles. (*Menage.*) A noose attached to a stock or handle, and nipped around the upper lip of a horse. It is twisted so as to be somewhat painful, in order to give the command of the head to the person holding the same. It enables a man to hold the horse's head aloft to keep him from biting, occupy his attention, and measurably prevent his kicking.

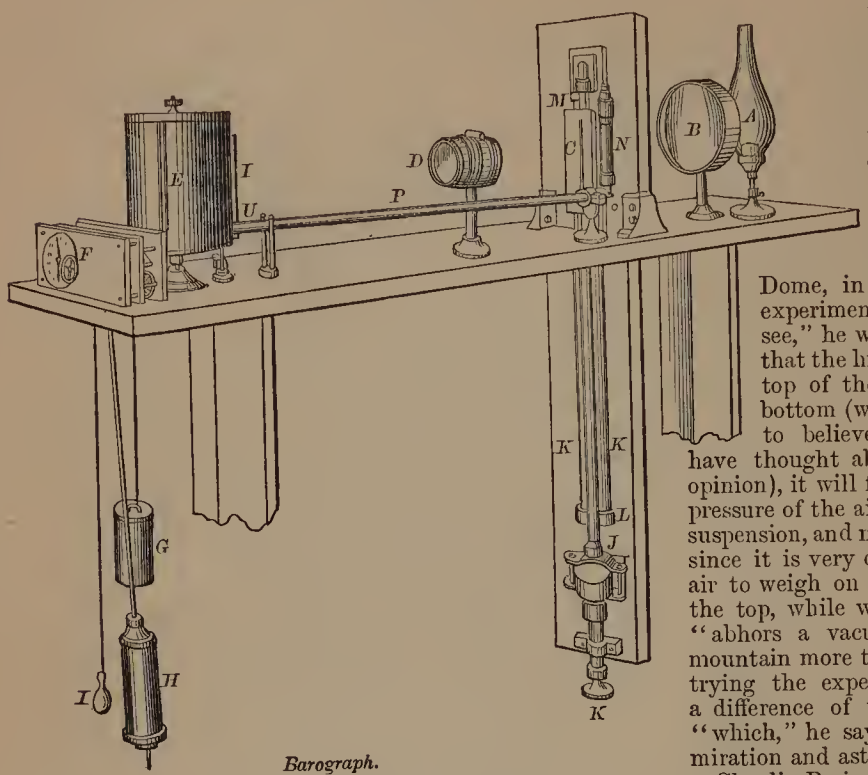
Bar'o-graph. An instrument for recording automatically the variations of atmospheric pressure.

In Fig. 569 this is effected by means of photography. The operative and recording parts are inclosed in a case (which in the figure is supposed to be removed) which rests upon the horizontal slab, and entirely excludes the entrance of light except through the slit *C*. *A* is a gas-burner, the light from which is thrown by the condenser *B* over the top of the mercurial column in the barometer-tube *J*, and passing through the photographic lens *D*, is concentrated on a strip of sensitized paper wound around the cylinder *E*, which is, by clockwork mechanism at *F*, made to revolve once in forty-eight hours.

The image of that portion of the slit *C* above the mercurial column is thus caused to form a continuous dark band of irregular width on the paper, becoming narrower as the mercury rises, and widening as it descends in the tube, the width of the band indicating not only the relative changes, but absolute hight of the barometer. A shutter operated by the clock-

work cuts off the light for four minutes at the end of each second hour, leaving a vertical white time-line on the paper.

Fig 569.



Barograph.

By the expansion of a zinc rod on each side of the barometer-tube, in connection with a glass rod and lever, thermometric changes are made, and the true barometric changes, with corrections for temperature, are photographically recorded.

Brooke's Self-Registering Barometer. Upon the column of mercury is a float carrying a mirror, on which a pencil of light is thrown. The case is inclosed so as to exclude all other light, and the beam is reflected by the mirror upon a traveling slip of paper indicating the extent and time of barometric changes.

Ba'ro-ma-crom'e-ter. An instrument for ascertaining the weight and length of infants.

Ba-rom'e-ter. (*Meteorology.*) An instrument for determining the weight or pressure of the atmosphere. Invented by Torricelli about the year 1643.

Barometers are variously named from differences in construction, mounting, fitting, etc.; e. g.: —

Aneroid.	Minimum barometer.
Holosteric barometer.	Mountain barometer.
Hypsometer.	Pediment barometer.
Long-range barometer.	Self-registering barometer.
Marine barometer.	Sympiesometer.
Maximum barometer.	Wheel barometer.

It is related that the pump-makers of Cosmo de Medici tried to raise water over 32 feet by means of a sucking pump, but failed to raise it over 31 feet. They applied to Galileo to resolve the difficulty. He was unable to do it, but bade them accept the fact. His disciple Torricelli investigated the subject, and found that the force, whatever it was, raised a column of mercury only 30 inches, which he judged to be the equivalent of the 31 feet of water, and hence deduced that the moving agent was not a nameless "horror of a vacuum," — a term which covered the ignorance of the real cause, — but was the pressure of the air upon the liquid; and that this pressure was equal to about 15 pounds to the square inch.

In 1647, Pascal showed practically that the hight of the mercurial column was affected by carrying the inverted tube to the top of an eminence. He made the experiment on a church-steeple in Paris. To test the matter more completely, he wrote to his brother-in-law Perrier, who lived near the Puy de Dome, in Auvergne, to repeat the experiment on that mountain. "You see," he writes, "that if it happens that the hight of the mercury on the top of the hill be less than at the bottom (which I have many reasons to believe, though all those who have thought about it are of a different opinion), it will follow that the weight and pressure of the air are the sole cause of this suspension, and not the horror of a vacuum; since it is very certain that there is more air to weigh on it at the bottom than on the top, while we cannot say that nature "abhors a vacuum" at the foot of a mountain more than on its summit." On trying the experiment, M. Perrier found a difference of three inches of mercury, "which," he says, "ravished us with admiration and astonishment."

Claudio Beriguardi, at Pisa, is said, however, to have used the barometer for determination of hights five years earlier than this. It is certain that the varying weight of the atmosphere at different hights was known before Torricelli.

Alhazen the Saracen, A. D. 1100, was aware that the atmosphere decreases in density with increase of hight, and therefrom explained the fact that a ray of light entering it obliquely follows a curvilinear path, which is concave towards the earth. He showed that a body will weigh differently in a rare and in a dense atmosphere, and calculated that the hight of the atmosphere is nearly 58½ miles, anticipating the discovery of Torricelli by several centuries. "The Book of the Balance of Wisdom," by Al Khazini (perhaps the same as Alhazen), gives a number of other luminous statements on mechanics. We take the liberty here of stating that he also wrote on the doctrine of the progressive development of animal forms, but did not reach the Darwinian conclusion. "Not," as he says, "that man was once a bull, and was then changed into an ass, and afterward into a horse, and after that into an ape, and finally became a man." This, he states, is only a misrepresentation by "common people" of what is really meant.

There is yet some difference between the true theory of progression and the doctrine of the Vedas, the Institutes of Menu (contemporary with Elijah and Homer, and the teaching of Pythagoras, 540 B. C. Rosalind, the charming, refers to the latter, apropos of finding the poetry tacked to the palm-tree: —

"I never was so berhymed since Pythagoras' time that I was an Irish rat, which I can hardly remember." — *As you Like It.*

The pious Moslem prays that the All-Merciful will, in the Day of Judgment, take pity on the soul of Abu-r-Raihân, who first compiled a table of specific gravities, the discovery of the great Archimedes thirteen

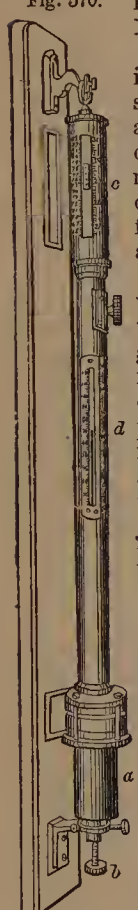
hundred years before. Our own Draper desires to add a clause associating in this prayer the name of "*Alhazen*, who first traced the curvilinear path of a ray of light through the air." It would not be hard to find good reason for associating the name of Draper with the illustrious two.

The barometer in its ordinary form consists of a tube 34 inches in length, closed at the top, exhausted of air, and with its lower open end plunged in a cup of mercury which ascends in the tube by the pressure of the atmosphere. Changes in the weight of the atmosphere raise or lower the hight of the mercurial column ; and a graduated scale alongside the tube, and embracing the range of motion, enables the reading of the variations.

The wheel barometer has a recurved tube in which the mercury ascends and descends, thereby actuating a float which connects by a cord to the axis of an index-finger, which rotates on a graduated dial. It was contrived by Hooke in 1688, the year that the great Dutchman, William of Orange, came to England.

The pendent or marine barometer is suspended on gimbals, which enable it to maintain its verticality during the rolling and pitching motions of a ship, and has a contraction at the bottom of the tube to obviate oscillations of the mercury. It was introduced about the year 1698 – 1700.

Fig. 570.



Standard Barometer.

The invention of the aneroid barometer is attributed to Conti, 1798, or to Vidi, 1804.

In the aneroid barometer (which, as its name implies, has no liquid) the pressure of the atmosphere is exerted upon an elastic metallic diaphragm above a chamber partially exhausted of air. The motions of the diaphragm, due to changes of pressure, are transferred to an index-finger which traverses in connection with a graduated scale. See ANEROID.

Barometers have been constructed in which the tube and cistern were filled with water instead of mercury. The great length of the column (nearly 34 feet at ordinary pressures) renders it extremely susceptible to slight atmospheric changes ; so much so that even momentary fluctuations can be observed at times during storms : but the difficulties in constructing and keeping in adjustment a barometer of this kind have prevented its coming into practical use. It would obviously be useless at temperatures below 32° F.

A standard barometer is one made with peculiar care, to serve as a standard of comparison for less costly instruments of the kind, or for use in meteorological observations, etc., where great accuracy and susceptibility are desired. The tube has in some cases a bore of an inch or upward.

a is the mercury-cup, *b* the adjusting screw, *c* the vernier, *d* the thermometer for data in making the corrections for temperature.

In reading the barometer two corrections are necessary : —

1. For the *capillarity*, or depression of the mercury in the tube.

2. For the temperature.

Pure mercury in a glass tube assumes a convex surface, and the convexity is greatest in tubes of small diameter.

The following is Ivory's scale, giving the corrections for tubes of different diameters : —

Diameter of Tube. Inches.	Depression. Inches.	Diameter of Tube. Inches.	Depression. Inches.
.10	.1403	.40	.0153
.15	.0863	.45	.0112
.20	.0581	.50	.0083
.25	.0407	.60	.0044
.30	.0292	.70	.0023
.35	.0211	.80	.0012

In siphon barometers, as the depression is equal in each leg of the tube, no correction is necessary.

The correction for temperature involves the consideration of the expansion of the mercury and also of the graduated scale. The latter, being minute, is, however, generally disregarded, and that of the mercury being .0001001 for each degree Fahrenheit, it has been usual to subtract from the reading $\frac{1}{10000}$ of the observed altitude for every degree of Fahrenheit above 32°. An example of the correction will stand thus : —

Thermometer, 54°.

Barometer, 30 inches.

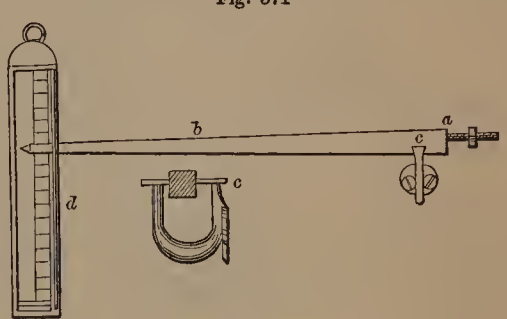
$(54 - 32) \times 30 \times .0001 = .066$, to be subtracted from 30 inches. Result, 29.934 inches.

Calculated correction tables are published.

The holosteric barometer is one in which a fluid is dispensed with. The usual form is the ANEROID (which see). The Vidi aneroid has a metallic diaphragm; the Bourdon aneroid has a bent tube capable of flexion. See BOURDON BAROMETER.

A form of holosteric barometer is constructed on a principle similar to that of the *hygrometric balance*. Its action depends on the different specific gravities

Fig. 571



Balance Barometer.

of a short metallic arm *a* and a long and bulky wooden arm *b*, balanced on a pivot *c* at their common center of gravity ; the long wooden arm, displacing a greater bulk of air in proportion to its weight than the other, is depressed by the rarification and elevated by the condensation of the atmosphere, causing the two arms to oscillate about the sustaining pivot, the variations being shown by a scale *d*, to which the longer arm points.

From a manual compiled by Rear-Admiral Fitzroy of the English navy, and published by the Board of Trade, the following is condensed : —

The barometer shows changes in the weight of the atmosphere, if any occur.

Changes in the level of the mercury are more emphatic than actual elevation.

If the mercury, standing relatively high, should fall, it presages a change, but not so great a one as if the mercury stood lower and fell to the same extent. The converse is also true.

The barometer foretells coming weather rather than indicates the present. The longer the interval between the sign and the change, the longer said altered weather will last. The converse is also true.

The barometer being at medium hight and rising, the thermometer falling indicates dry weather. The converse: barometer medium and falling, thermometer rising, rain; thermometer falling, snow.

The rising or falling condition of the mercury may be observed upon its upper surface; convex if rising, concave if falling.

Fluttering changes indicate unsettled weather; slow movements the contrary. Rapid and continued fall is a sign of a storm, the wind being from the north if the barometer is low (for the season), and from the south if the thermometer is high.

Three causes affect a barometer: —

1. The direction of the wind.
2. The moisture of the air.
3. The force of the wind.

When they act separately they act less strongly, and when coincidently the change in the barometer is greatest.

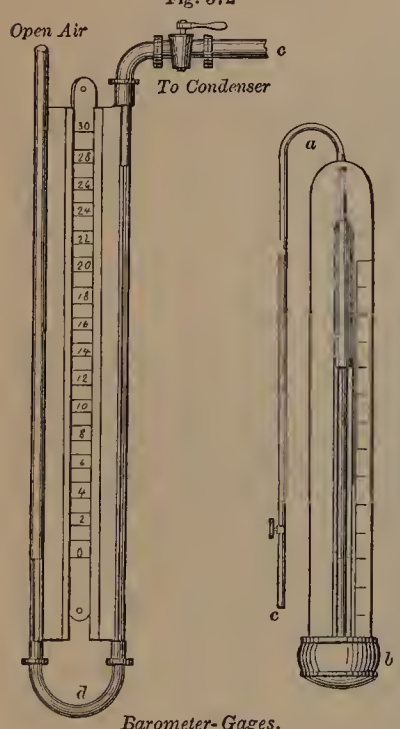
Ba-rom'e-ter-gage. (*Steam-Engine.*) An attachment to a boiler, condenser, or other chamber, which indicates the state of the vacuum.

When a boiler is allowed to cool, the steam condenses, and a more or less perfect vacuum is formed therein, subjecting the boiler to heavy external atmospheric pressure. This contingency is usually met by an inlet safety-valve, called a *vacuum*-valve.

When a condenser is in operation, it is desirable to know the condition of the vacuum, as a test of the efficiency of the air-pump.

When a receiver is partially exhausted for experimental purposes, it is desirable to obtain an indication of the tenuity of the contained air.

Fig. 572



Barometer-Gages.

The *Barometer-gage* is a bent glass tube *a*, one end being plunged in a cistern of mercury *b*, and the other end *c* connecting with a steam-boiler, condenser, or tank, as the case may be.

When the jet of water condenses the steam in the condenser, a partial vacuum is formed, and the external atmosphere is in excess of the internal pressure, so that the mercury is caused to ascend the tube.

Another form is an inverted siphon, the mercury being contained in the bend *d*, as in the *Steam-Pressure Gages*.

Bar-o-met'ri-cal A-e'ri-om'e-ter. (*Meteorology.*) An inverted siphon used for approximately determining the relative specific gravities of immiscible fluids, as oil and water, or water and mercury. For instance, if mercury be poured in one limb and water into the other, and the stop-cock at *c* be turned so as to establish a communication between them, it will be found that an inch of mercury in one limb will balance 13½ inches of water in the other, showing the relative specific gravities of the two fluids to be as 13½ to one.

Fig. 573.

Barometrical Aeriometer.

Bar-o-met'ro-graph. (*Meteorology.*) An instrument by which the variations of atmospheric pressure are automatically recorded on a sheet of paper.

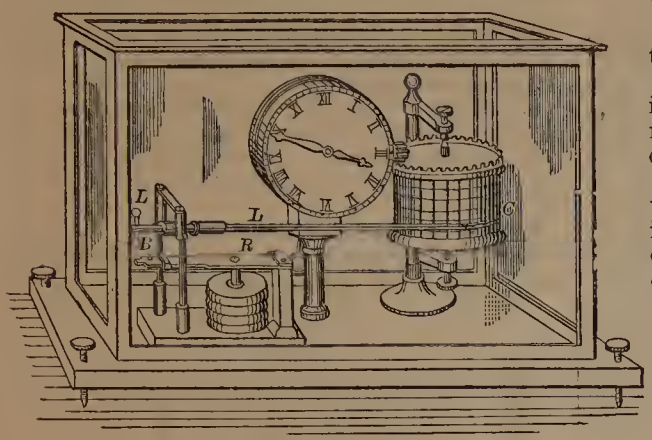
Napier's instrument, patented in 1848, is intended to mark the variations of atmospheric pressure during an entire period of 24 hours. Connected with the barometer-tube is a vertical spindle carrying a card which has on its surface a number of radial lines and concentric circles; the radial lines represent fractions of inches, and the concentric circles represent portions of time. Above the card is a lever carrying a vertical pricker, which is made to rise and fall at certain regular intervals of time, and to travel from the inner concentric circle to the outer one once in 24 hours. On the vertical spindle, and underneath the card, is fastened a grooved wheel, around which is passed a cord, while the other end is made fast to a float resting upon a column of mercury in a tube. The card has a fixed point representing 29.5 inches, which, at the commencement, is placed underneath the pricker. As the column of mercury rises or falls by the varying pressure of the atmosphere, the printed card will travel to the left or the right accordingly; and the variation of hight will be indicated by the distance of the punctured lines from the starting-point on either side.

A self-registering barometer, recently invented in France, is shown in the accompanying cut. The records are continuous and comparable, and are produced by the variations of an aneroid. The pressure of the atmosphere affects four metallic boxes, as in the ordinary aneroid, having their upper and under faces undulated; a vacuum is made in each of them separately, and they are attached together in one series, so that for an equivalent variation of pressure the movement is four times greater than it is for one box only. A very strong flat steel spring *R*, acts upon the barometric boxes in an opposite direction to the atmospheric pressure. This spring controls the indicating lever *L L* by means of a connecting piece at the point *B*; this connector receives the action from the extremity of the spring, and communicates it to the lever *L L* at a point very close to its axis, from whence it follows that a considerable multiplication of movements is the result.

The indications of the movements of the lever are registered in the following manner: A cylinder *C* is revolved by the regular movement of an ordinary pendulum timepiece; it makes a complete revolution in one week, and carries a glazed paper which has been smoked black by means of a candle. At the extremity of the lever is a very fine spring, pointed at the end, which rests upon the cylinder and traces a white line upon the black ground. At the end of each week the paper is changed for a fresh one, the record on the old one being protected by a coat of varnish.

The action of the self-registering and printing barometer, invented by Professor Hough of the Albany Observatory, depends upon the making and breaking of an electric circuit by the rising and falling of the mercury, for the communication of impulses to electro-magnets, which unlock a train of clock-work so devised as not only to describe a constant curve upon a piece of paper, representing the height

Fig. 574.



French Barometrograph.

of the column at any time of day and night for many days in succession, but also to print upon pages, which may be subsequently bound, the hights of the column as often as may be desired, thus making a printed record. The barometer employed has a siphon tube.

Bar'o-scope. (*Meteorology.*) An instrument which indicates the variations in weight of the atmosphere without indicating its absolute pressure. A weather-glass. Of this class are the instruments called prognosticators, or storm-glasses, consisting of a tube containing a clear liquid in which a flocculent substance floats, rising and falling with variations in the weight of the atmospheric column, and thus indicating the kind of weather which may be expected.

Somewhat allied to these are instruments in which a flocculent substance is suspended in a menstruum; the assumption of a milky appearance by the material indicates an excess of moisture in the air, and prognosticates rain.

The wheel barometer of Hooke is also a baroscope, as its changes and indications are made visible by means of a float in the mercury, whose counterbalanced suspension-string moves a hand on an index-circle.

Ba-rouche'. (*Vehicle.*) A four-wheeled carriage, having a falling top. It has two seats inside, arranged so that four persons can sit two facing other two, the seat for the driver being outside.

Bar-pump. (*Hydraulics.*) A small boat-pump for raising water, oil, etc., from large casks. Probably from *Burr-pump*. See BARE-PUMP.

Bar-quan-tine'. (*Nautical.*) A three-masted vessel, square-rigged on the foremast, and fore-and-aft rigged on the main and mizzen. Commonly found on the Northern lakes. Also spelt *barkantine*.

Barque. (*Nautical.*) A three-masted vessel whose fore and main masts are *square-rigged*, like those of a ship, and whose mizzen is *fore-and-aft* rigged, like a schooner.

Bar'ra-can. (*Fabric.*) A thick, strong stuff, known by this and similar names in most of the languages of Europe and Western Asia. It is made in Armenia and Persia of camel's hair, like *camlet*, whose name also indicates that its material is derived from the same animal. The name has been preserved, while the fabric has been made of other materials, — wool, flax, and cotton.

It was during the wool stage that the memorable Falstaff celebrated his achievements: "Four rogues in buckram (*barracan*) set at me."

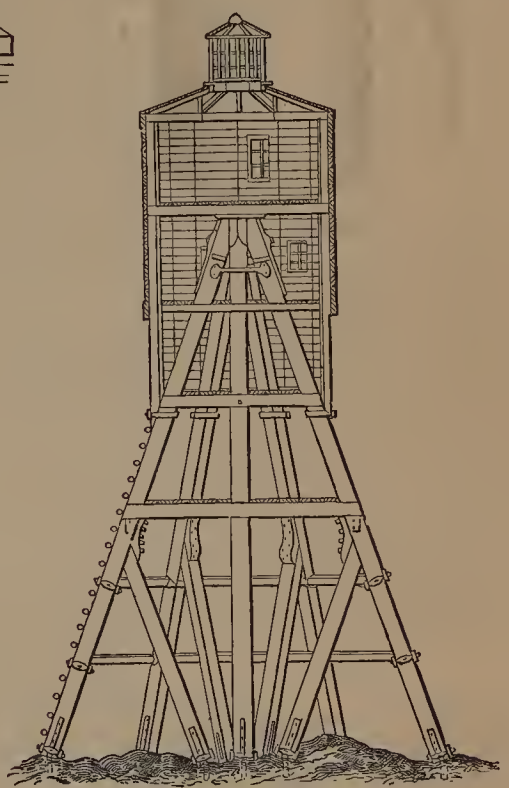
An article called *barracan* is yet used in Europe, and in some countries is mainly cotton, resembling *fustian*.

The old Roman toga was commonly made of this material.

Bar'rack. (*Engineering.*) A temporary building for quartering soldiers or for workmen. Permanent buildings, also, designed exclusively for occupancy by soldiers, are generally so called.

Also a structure erected for sheltering the workmen where work is progressing in an isolated position, to which access is at times difficult or impossible, on account of the state of the tide or weather. Of this class were the

Fig. 575.



Barrack on Skerryvore Rock.

temporary dwellings erected by the Stevensons on the Bell Rock in the Frith of Forth, and on the Skerryvore Rocks, about 12 miles W. S. W. of the island of Tyree, Argyllshire, Scotland, for the protection of the men, provisions, tools, and a portion of the materials.

Bar'rage. 1. (*Fabric.*) A Normandy fabric made of linen interwoven with worsted flowers.

2. (*Hydraulic Engineering.*) *Barrage* is a French word, signifying, in general, an artificial obstruction placed in a water-course in order to obtain an increased depth for navigation, irrigation, or other purposes. *Barrage-fixe* is a permanent dam of masonry. *Barrage-mobile* is a dam having a sluice by which the flow of water may be regulated.

Bar'ras. (*Fabric.*) A kind of packing-cloth.

Bar'rel. A word applied to hollow cylindrical objects, such as —

1. (*Pump.*) The piston-chamber of a pump.

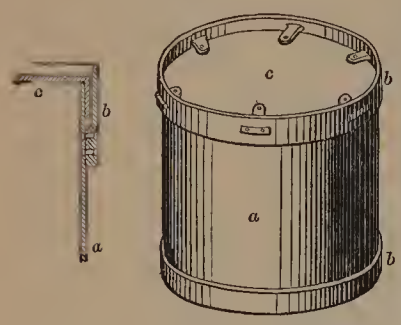
2. A cask for containing liquids, usually having a capacity of from 30 to 45 gallons.

A cask for certain kinds of provisions, — flour, fruits, vegetables, etc., — holding 196 pounds of flour (American custom), or about 2½ bushels of fruit, varying according to the customary practice in regard to *striking* or *heaping* the measure.

A measure of ear-corn in the Southern States, shelling 2½ bushels.

The DICKENSON Patent Wrought-Iron Barrels, used in the British navy, have a cylindrical form, with a soldered seam. An iron hoop *b* is riveted to each end. This hoop has a rabbet, and the thickest part is riveted to the drum *a*, while the other portion forms a recess with the side of the drum for the reception of the flange of the head *c*, which is made by bending the periphery of the circular iron plate at a right angle to its plane. A packing of greased hemp-bands is placed in the recess, the flange of the head driven in, and then the edge of the iron hoop is turned over against the bottom head, making an air and water-tight joint.

Fig. 576.



Dickenson's Wrought-Iron Barrel.

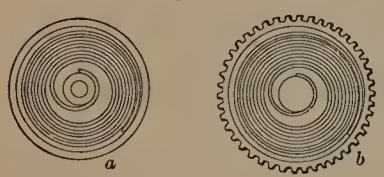
This is for the bottom head. The upper head is removable without damage to the package. The upper portion of the hoop is not flattened down as at the other end of the barrel, but a number of latch-bolts are pivoted to the cover, and catch into openings in the side of the hoop.

The metal is coated inside and out with canvas saturated with a composition of caoutchouc, 8; black resin, 4; Venice turpentine, 1.

This is digested, spread on the cloth, and the latter is then run between rollers.

3. (*Horology.*) *a*. The hollow cylinder or case containing the *mainspring* of a watch, or spring clock (*a*, Fig. 577). It is connected by a *chain* with the *fusee*, and by the winding of the latter the *chain* passes from the *barrel*, and the *mainspring* is *wound*. See FUSEE.

Fig. 577.



Barrels.

When the *fusee* cannot be introduced into a watch, owing to the flatness of the *movement*, the first wheel is attached to the *barrel*, which is then called a *going-barrel* (*b*, Fig. 577).

Stop-works are attached to regulate the action of the spring; that is, to prevent its being wound too tight or running down too far, using the middle power of the spring and rejecting its highest and lowest powers. This is particularly necessary in watches destitute of the *fusee*. See STOP-WORK.

b. The chamber of a spring-balance.

4. (*Fire-arms.*) The tube of a gun from which the projectile is discharged.

5. (*Music.*) The cylinder studded with pins by which the keys of a musical instrument are moved.

6. (*Metallurgy.*) A cylindrical vessel moving on an axis, for amalgamating, polishing (*tumbling-box*), or making gunpowder. In the latter case it is partially filled with bell-metal balls, and is called a *rolling-barrel*.

7. (*Nautical.*) *a*. The main piece of a capstan, between the *whelps* and the *pawl-rim*.

b. The cylinder around which the tiller-ropes are wound.

8. The sonorous portion of a bell, which is attached by the remaining portion, the *canon* or *ear*, to the suspensory arrangements.

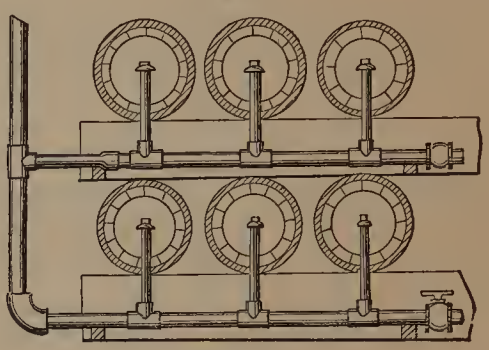
9. (*Pulley.*) The cylindrical portion of a drum or pulley on which the band laps.

10. (*Steam-Engine.*) The cylindrical portion of the locomotive boiler extending from the fire-box to the smoke-box.

Bar'rel-drain. A cylindrical drain.

Bar'rel-dry'er. A device for drying barrels after being coopered or washed, before refilling.

Fig. 578.

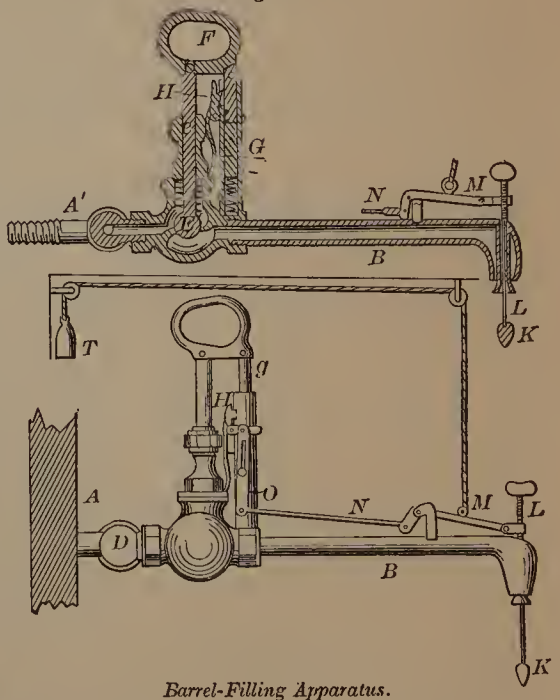


Barrel-Dryer.

The view (Fig. 578) is sectional, and shows two tiers of main steam-pipes with vertical branch-pipes extending upwardly through the bung-holes into the interiors of the casks.

Bar'rel-fill'er. (*Hydraulics.*) A device for filling casks, provided with an automatic arrangement for cutting off the supply of liquid in time to prevent

Fig. 579.



Barrel-Filling Apparatus.

overflow, or calling attention to the fact that the vessel is about full.

In one form, the rising of the liquid in the barrel is the means of stopping the flow. In Fig. 579, the tube *A' B* is jointed at *D*. The end bearing the float

K is inserted into the barrel to be filled, and, as the float rises, it, through the medium of the rod *L* and jointed lever *M N O*, releases the detent *H*, allowing a spring to force up the rod *g* and depress the rod *e*, closing the valve *E* and cutting off the supply. As the projecting spout *B* is lightened by the absence of the liquid, the counterpoise weight *T* lifts it clear of the bung-hole.

In another form, the liquid flows through a stop-cock to enter the barrel; when the latter is full, the liquid overflows into a chamber in which a float rises and operates a lever to close the stop-cock.

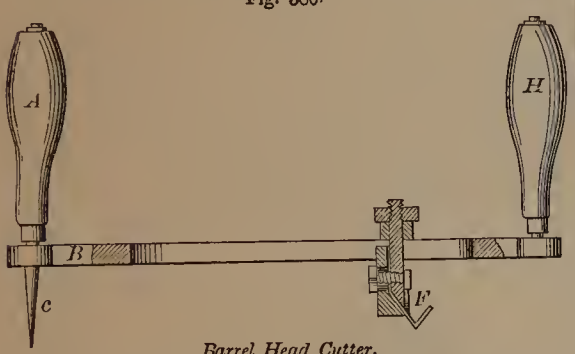
In another form, as the liquid rises and closes the air-exit, the air condensed in the upper part of the barrel passes through a duct in the faucet, and by pressure on a diaphragm operates a lever which closes the supply.

In some cases the elevation of the water-level operates a whistle, in another rings a bell. The ascending float, however, is the usual operative feature of the barrel-filler.

Bar'rel-fill'ing Gage. (*Hydraulics.*) An automatic indicator, used in connection with a faucet, to announce when the barrel is about full, so that the supply may be stopped. Some gages merely show the hight of the liquid in the barrel; others give an alarm when it attains a certain hight; others cut off the supply. See BARREL-FILLER.

Bar'rel-head Cut'ter. (*Coopering.*) *a.* A tool for rounding and chamfering barrel-heads. The

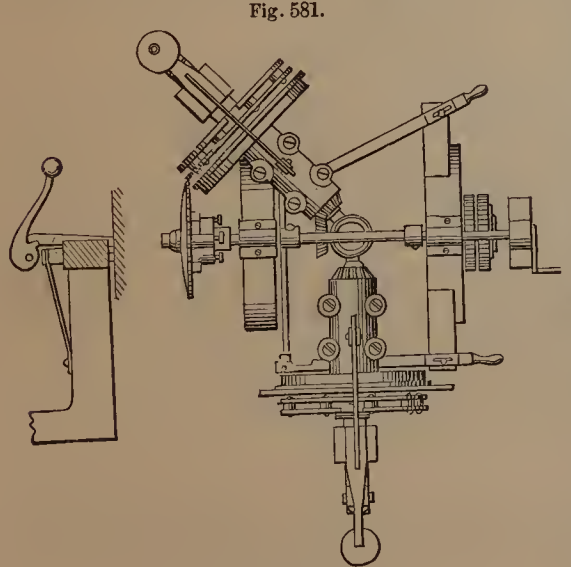
Fig. 580.



Barrel Head Cutter.

pivot *c* is stuck into the center of the head, and the tool rotated by the handle *H*. The angular cutter

Fig. 581.



Barrel-Header.

F is adjustable on the shank *B* of the tool, according to the radius of the barrel-head.

b. A machine for effecting the same purpose. In the example the blank is placed between the clamping disks, and the frame turned so as to bring the blank in contact with the disked saw; this movement also brings the bevel-wheel upon the arbor of the clamping-disks in connection with its motive-wheel upon the saw-shaft. The frame is duplicated, so that while one blank is being operated on, another may be clamped in position.

Bar'rel-head Hold'er. (*Coopering.*) A clamp consisting of a pair of jaws for holding barrel-heads in position while being trimmed around the edges.

Bar'rel-hoop'ing Ma-chine'. (*Coopering.*) A machine for setting the hoops on a barrel. A circular ring has pendent drivers, and is reciprocated by a rack-bar and pinion. The assembled staves are placed in upright position, and the hoops driven thereon by the downward motion of the drivers.

Bar'rel-loom. (*Weaving.*) *a.* A loom in which a barrel, usually a square prism, receives the perforated cards which determine the figures. A *jacquard loom.*

b. One used for weaving figured fabrics; the rising and falling of the heddles which govern the warps being accomplished through the agency of pins on the revolving barrel.

Bar'rel-mak'ing Ma-chine'. (*Coopering.*) A machine or series of machines by which some principal part of the process of, or the series of processes in, making barrels is performed.

BROWN's English Patent, 1825, embraces the following series of devices: —

1. A circular saw, with a bench and slide-rest, having an adjustable guide consisting of a flexible bar, which is bent to the curve desired for the edge of the stave. A piece of wood of proper dimensions is clamped to the slide-rest, which is advanced by hand along the guide and presented to the circular saw, which gives the proper curve to the edge of the stave.

2. An apparatus with cutters, attached to a revolving standard, by means of which the staves, secured by temporary hoops, are crozed.

3. An apparatus somewhat similar to the above, in which the straight pieces of wood for forming the heads are held together, cut to the circular figure required, and beveled.

4. A machine in which the cask, after having been assembled and headed up by hand in the usual way, is revolved, while a cutting tool is made to traverse along its exterior, forming a smooth surface.

The arrangement of the machinery at Glen's Falls, N. Y., consists of three machines: the first for cutting the staves to the required length, finishing the heads, and making the croze; the second jointing the staves in packs; the third forming the heads.

Bar'rel-or'gan. (*Music.*) An instrument in which the notes are sounded by means of pins or staples, arranged as to time and place on the surface of a cylinder which is rotated by hand. See HAND-ORGAN.

Bar'rel-pen. A steel pen which has a split cylindrical shank, adapting it to slip upon a round holder.

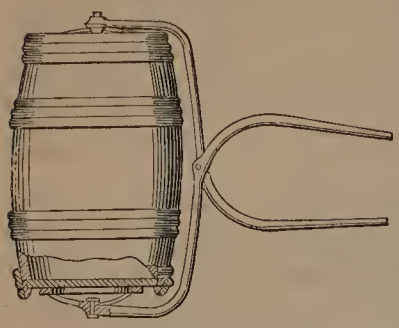
Bar'rel-pro'cess. A mode of extracting precious metals from ores. See AMALGAMATOR.

Bar'rel-roll'er. A device for clamping the ends of a barrel, and manipulating it so as to allow it to turn freely when rolled along on its bilge.

A pair of handles of a convenient size are crossed, and pivoted at the point of crossing like a pair of scissors. The opposite ends of the handles are each

provided with a disk of a diameter somewhat less than that of the common barrel-head. Each disk is pivoted at its center to its supporting arm and so as to revolve freely. The handles are of such form that the disks may be applied, one at each end of a barrel, and pressed closely against it, whereupon the barrel may be easily rolled.

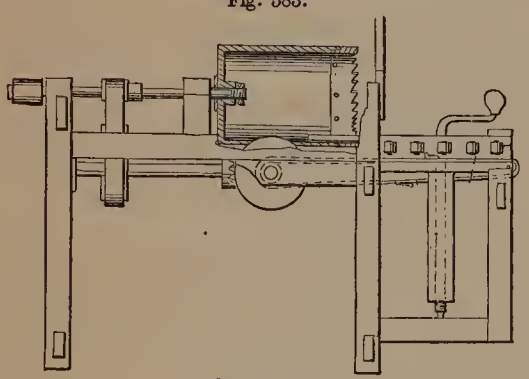
Fig. 582.



Barrel-Roller.

Bar'rel-saw. (*Coopering.*) A cylindrical saw for sawing staves, etc., to a curved form. They are afterward bent to the required longitudinal curve. The saw is mounted on a table, and means are provided for keeping it up to the work and retracting it therefrom.

Fig. 583.



Barrel-Saw.

Cylindrical saws are also used for sawing chair-backs, brush-backs, and fellies.

Bar'rel-screw. (*Shipwrighting.*) A form of screw-jack used in a shipwright's yard to move heavy timbers or assist in launching.

Bar'rel-set'ter. (*Gun-making.*) A cylindrical mandrel used by armorers for straightening the barrel of a fire-arm and in *truing* the bore or exterior surface.

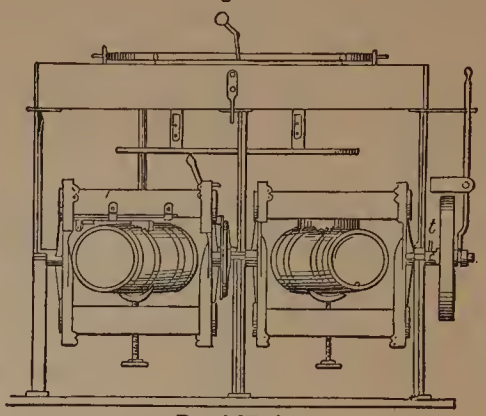
Bar'rel-vault. (*Masonry.*) A cylindrical vault.

Bar'rel-vise. (*Gun-smithing.*) A bench-vise, having a longitudinal groove in its jaws to fit it for the reception of a gun-barrel, which may be protected from direct contact of the jaws of the vise by sheet-lead or other soft metal cheeks.

Bar'rel-wash'er. (*Brewing.*) A machine in which casks are cleansed after use, preparatory to refilling.

In one example, the barrels are clamped in the frames that turn on pivots in journals in an iron frame. The barrels are arranged at an angle to their line of rotation by a clamp with a corrugated surface that curves to suit the bilge of the barrel. To vary the angle to the plane of rotation of all the barrels simultaneously, the clasps are mounted in circular guide-ways on the clamping rails, so that they may vibrate in arcs of which the axis of rotation of the frame forms the center. This causes a swashing motion of the water endways of the barrel, by which its interior is cleansed.

Fig. 584.



Barrel-Washer.

Bar-ret-tees'. (*Fabric.*) A kind of plain silk.

Bar'rier. (*Fortification.*) An obstacle, such as a palisade or stockade, for defending an entrance to a fortification. It is provided with a central gate formed of strong upright timbers, connected by transverse beams at top and bottom and a diagonal brace.

Bar'rier-gate. (*Fortification.*) A gate closing the entrance through a stockade or barrier.

Bar'row. 1. (*Mining.*) A heap of *attle*, or rubbish.

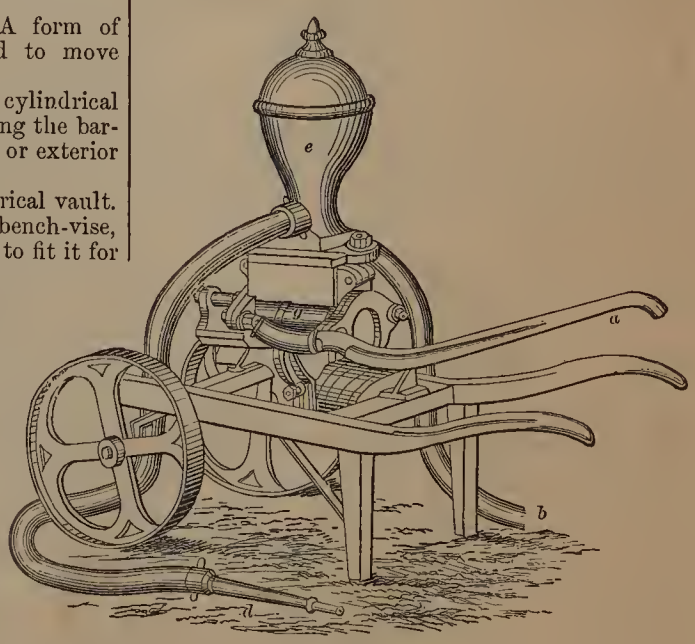
2. (*Vehicle.*) A light carriage for transporting articles, moved by hand. See HAND-BARROW and WHEELBARROW.

3. In salt-works, a wicker case in which the salt is put to drain.

Bar'row-pump. (*Hydraulics.*) A combined suction and force pump, rendered portable by being mounted on a two-wheeled barrow, and adapted for agricultural and fire-engine purposes.

In the illustration shown, the pump is double-acting, and is worked by the lever *a*, which projects over and between the handles of the barrow. *b* is the suction-hose; *d*, discharge-nozzle; *e*, air-chamber; *g*, cylinder.

Fig. 585.

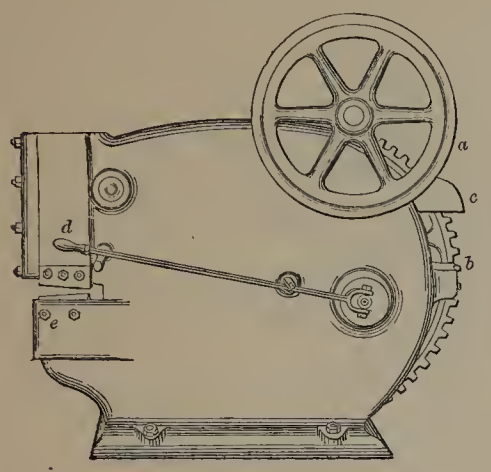


Barrow-Pump.

Bar-share Plow. (*Agriculture.*) One having a bar extending backward from the point of the share. Used in tending crops, laying out corn-rows, etc.

Bar-shear. (*Metal-working.*) A machine for cutting metallic bars. It consists of a very strong

Fig. 586.



Bar-Shear.

frame, having a fixed lower blade *c* and a vertically reciprocating upper blade *d*, between which the bar is sheared. *a* is the fly-wheel, *b* the main gear-wheel on the axis of the cam (hidden in the interior of the casing), which works the tail of the lever *c* and reciprocates the jaw *d*. See BAR-CUTTER.

Bar-shoe. (*Farriery.*) A horseshoe which is not open at the heel, but is continued round at the rear. It is used with horses which are liable to contraction of the heel, to spread that part of the foot.

Bar-shot. (*Ordnance.*) A projectile formerly used, consisting of two cannon-balls, or half-balls, united by a bar of iron, and employed for severing the rigging of vessels, as well as for field and fort artillery.

Shot used in proving ordnance may be considered as belonging to this class, consisting, as they do, of a bar with hemispherical ends, weighing twice or three times that of the solid shot used in service.

Bar-ti-zan'. (*Fortification.*) The overhanging turrets of a battlement.

Bar'ut-ine. (*Fabric.*) A kind of Persian silk.

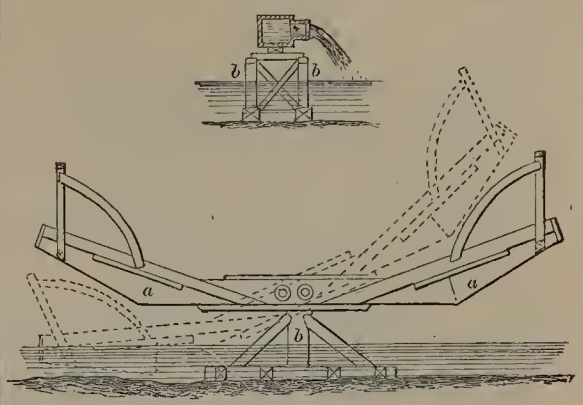
Ba-salt'ing. A process for utilizing the scoriæ of blast-furnaces for making paving and building blocks.

Ba-sane'. (*Leather.*) French tanned sheep-skins for bookbinding. *Bawsin.*

Bas'cule. (Fr. *sec-saw.*) A form of bailing-scoop used by Perronet at the Bridge of Orleans was worked by 20 men, 10 at each end. 600 motions were given to it per hour, and at each motion 4 cubic feet of water were raised 3 feet high; 2,400 cubic feet per hour.

It consists of a pair of scoops *a a* on a single frame, which is pivoted to oscillate upon bearings on the summit of posts *b*, secured to a frame planted on the bottom of the river, pond, or inclosure to be drained. See BAILING-SCOOP.

Fig. 587.

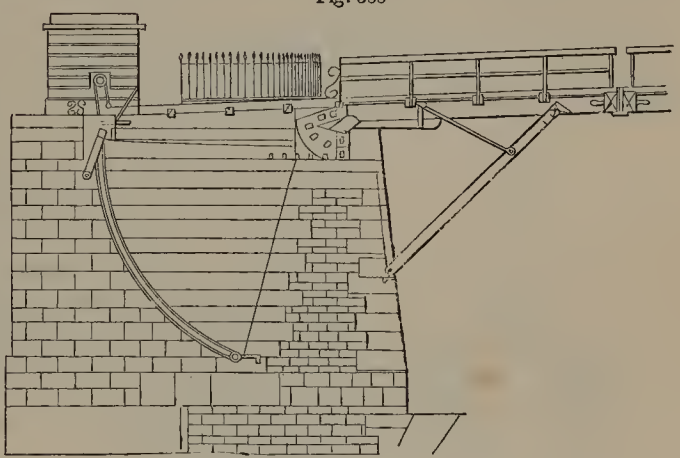


Perronet's Bascule.

Bas'cule Bridge. A counterpoise drawbridge which oscillates in a vertical plane; the inner portion descends into a pit, while the outer ascends and closes the gateway.

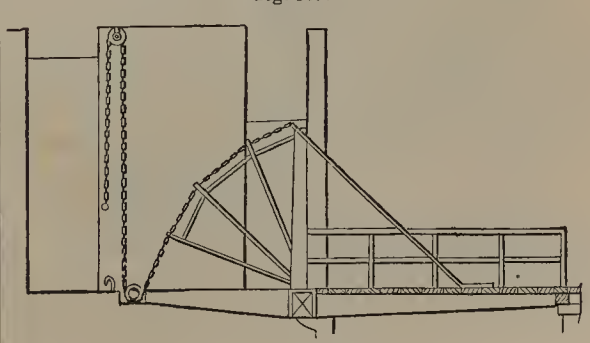
A bridge which has its truck simply hinged to the edge of the scarp or curbing, and which is lifted by weight or windlass, is classed as a LIFTING-BRIDGE (which see). The *bascule* has an inner portion of roadway, which acts as a counterpoise to the portion which projects over the water-way. The inner portion descends into a dry well when the bridge is lifted into a vertical position, the outer portion closing the opening in the wall outside of the portcullis, if there be one. This form of bridge was not uncommon in the castles of the feudal times, when the rich owned the poor, and learning had no refuge but in the Church.

Fig. 588



Bascule at Brussels.

Fig. 589.



Bascule Neuf Brisack.

A *bascule bridge* at Brussels, called a *balancing-bridge*, has an overweighed land end, so that it assumes the vertical when a chock beneath its inner end is removed. The land end works in a quadrantal pit lined with iron. The strut that supports the land end is footed upon a set-off in the masonry, and a swinging strut limits the depression of the bridge at its outer end. When tilted, the bridge is held in position by a rack and pinion.

Instead of the heavily counter-weighted platform, a pendent weight, chain, and pulleys may act upon a vertical arm to raise and lower the platform, which oscillates upon a horizontal axis.

Base. 1. (*Ordnance.*) The protuberant rear portion of a gun, between the *knob* of the *cascabel* and the *base-ring*.

The *base* is the middle member of the *cascabel* when the piece has a base-ring and knob. In the simplicity of modern pieces, many mere ornaments and extraneous matters are omitted. The *base* is always present, forming the rounded contour at the rear of the breech.

2. (*Carpentry.*) The skirting-board next to the floor of a room.

3. (*Surveying.*) The main line of a survey, ascertained by actual measurement, upon which the subsequent trigonometrical operations are founded.

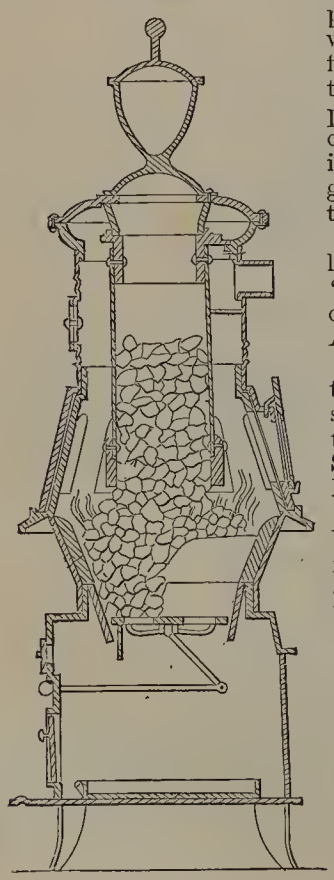
4. (*Architecture.*) The lower part of a structure: of a building it may constitute a basement; of a column it may consist of *base-moldings* and *plinth*.

5. (*Fortification.*) The line connecting the salient angles of two bastions.

6. (*Dentistry.*) A foundation resting immediately upon the gums, on or into which the artificial teeth are placed.

Base-burn'ing Fur'nace. A furnace or stove in which the fuel is contained in a hopper or chamber, from which it is fed to the fire as the lower stratum burns. The supply is thus continuous, the hopper holding a supply for any given time, according to its capacity.

Fig. 590.



Base-Burning Stove.

The idea seems to have originated in the "Constant Furnace" of the alchemists. See ATHANOR.

James Watt contrived a smoke-consuming furnace on that principle. See SMOKE-CONSUMING FURNACE.

The principle of the base-burner is also found in the furnace exhibited in 1685 by M. Delasme, at the fair of St. Germain. It consisted of a long tube like an inverted siphon, the longest leg of which formed the chimney and the shortest the furnace. The fuel was deposited on a grating near the top of the shortest leg, being supplied from above. Soon after ignition of the fuel, heat was communicated to the longest leg or chimney, and by that means a current of air was caused to pass downward through the fuel and under the grate, where the smoke was consumed.

Base-burn'ing Stove. One having a magazine to hold a supply of fuel, which falls out at the bottom as that in the fire-pot becomes consumed. In the example, the grate is arranged to be dumped without opening the base of the stove, thus preventing the escape of dust. The reservoir is constructed in three sections. Above the mica windows is a register for the purpose of admitting air to the fire.

Base'ment. (*Architecture.*) The lower story or floor of a building; the story of a house below, or partly below, the level of the ground.

Base-plate. (*Machinery.*) The bottom plate, to which the frame of an engine or machine is fastened. A *bed-plate*.

Base-ring. (*Ordnance.*) A molding on the *breech* of a gun, between the *base* and the *first reinforce*. See CANNON.

Base-vi'ol. (*Music.*) An instrument of the violin kind, the largest of the class. It has four strings and eight stops, divided by semi-stops. It is played by a bow.

Bas'il. 1. (*Cutting-tools.*) The ground surface of a cutting-tool which forms an angle with the back; as of a chisel, graver, plane-bit, etc.

The broad-axe, adz, firmer and paring chisels, gouge, plane-bit, graver, have but a single *basil:* one face is permanent and straight; the sharpening is done upon the *basil*.

Chopping-axes, hatchets, machetes, stone-axes, bill-hooks, swords, tomahawks, turning-chisels, etc., have a double basil, if it may be so termed. They are sharpened equally on the two faces.

2. (*Leather.*) A sheep-skin tanned with bark, and of quality for making slippers.

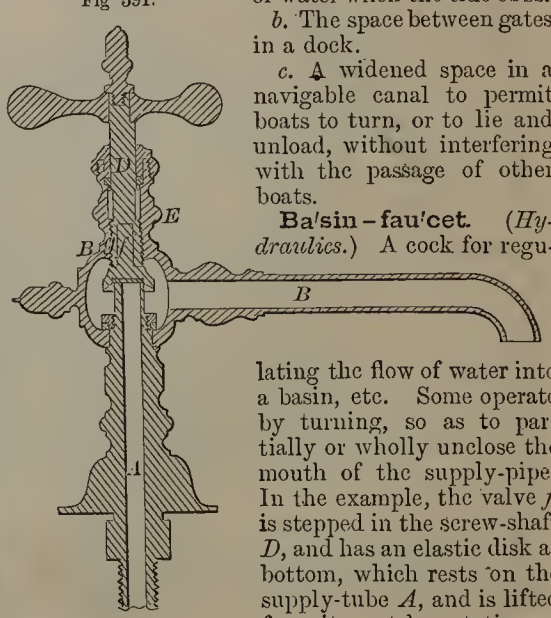
Bas'i-lisk. (*Ordnance.*) An old name for a long 48-pounder cannon; so called from the snakes which superseded the dolphins common on other guns.

Ba'sin. 1. (*Optics.*) The disk on an optician's stake, in which convex lenses are ground.

2. (*Hat-making.*) The iron mold in which a felt hat is formed.

3. (*Hydraulic Engineering.*) *a.* A wet-dock with gates to restrain the reflux of water when the tide ebbs.

Fig 591.



Basin-Faucet.

b. The space between gates in a dock.

c. A widened space in a navigable canal to permit boats to turn, or to lie and unload, without interfering with the passage of other boats.

Ba'sin-fau'cet. (*Hydraulics.*) A cock for regulating the flow of water into a basin, etc. Some operate by turning, so as to partially or wholly unclose the mouth of the supply-pipe. In the example, the valve *f* is stepped in the screw-shaft *D*, and has an elastic disk at bottom, which rests on the supply-tube *A*, and is lifted from its seat by rotation.

Other faucets operate by vertical pressure on a button or lever, which depresses a spring-valve and opens the water-way; the pressure being relieved, the efflux ceases.

Bas'ket. 1. A vessel made of flexible materials lapped or interwoven. The art of interweaving wands, leaves, and spliuts is of great antiquity. The ark of Moses was a basket of interwoven bulrushes, made water-tight by slime and pitch (Ex. ii. 3), 1571 B. C. The chief baker of Pharaoh dreamed that he had three white baskets upon his head filled with bake-meats, which probably meant cakes. This was 1717 B. C. (Gen. xl. 17.)

The ordinary use of the basket in gathering in the crop is indicated by the blessing of basket and store. (Deut. xxviii. 5.)

On opening one of the ancient tombs of Egypt, a lady's work-basket was found, containing the following articles, which may now be viewed by generations from twenty-five to thirty centuries subsequent to the time of the lady who used them. They are in the Abbott collection, New York City.

Two skeins of thread;
A small white *glass* bottle;
An ointment-box;
A toilet-box to contain kohl, for blacking the edges of the eyelids, as in the days of Jezebel;
A wooden netting-needle, charged with the original thread;
Two bronze needles;
One blade of a pair of scissors;
A piece of linen, partly darned;
Some bronze pins;
An ivory dress comb;
A wooden comb;
Four small ivory pegs, use uncertain;
A bronze spatula, for spreading unguents;
Some false hair, plaited.

Baskets from ancient Egypt, preserved in the Abbott Museum of Antiquities, New York City, are made of grass, reeds covered with leather, and of date-tree fiber.

Pliny refers to the suppleness and graceful slenderness of the osier willow, as fitting it for the weaving of baskets and many utensils employed in agriculture.

In ancient Egypt, wicker-work baskets were made of osiers and the stalks of the palm-leaf. They were made with and without handles, for various purposes, and of different sizes and shapes. Grain was sown from a basket; eggs, figs, and grapes are represented in baskets in the field and the store-room.

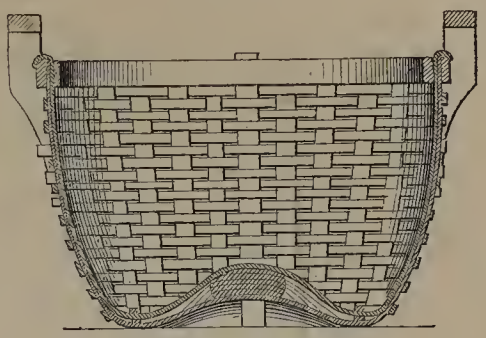
Baskets made of palm-leaves are preserved in the British Museum.

The ancient Britons excelled in making baskets, which were largely exported and sold for high prices at Rome. British articles were transported to Rome in baskets, and the British name for these hampers was there retained, — *bascuda*. The Welsh preserve it as *basgawd*. When Britain was first known to the Romans, the natives made boats of basket-work covered with hides, and boats made in a similar way are still used in parts of Wales. See CORACLE. Boats of split bamboo, woven like basket-work, are used in Hindostan, and in some parts of South America rush baskets capable of holding water are made by the natives.

A two-horse carriage of basket-work, termed a "Holstein wagon," is used in some parts of Europe, and this material is very commonly employed in the United States for the bodies of sleighs, and sometimes for pony phaetons. Rattan is, however, the neater and more desirable material.

For the finer kinds of baskets particularly, osier is the material most commonly used, but for a coarser

Fig. 592.



Splint Basket.

basket, strips of split hickory, oak, or black ash, are frequently employed. Osiers are prepared for the basket-maker by being split asunder or stripped of their bark, according to the kind of work for which they are intended. Previous to being stripped, they require to be soaked in water, and the stripping is performed by drawing the willows through iron *brakes*, which remove the bark; they are next cleaned by a sharp knife, and exposed to the sun and air. The barked or white osiers are assorted into bundles or fagots according to size, the larger ones being used for the strong work in the skeleton of the basket, and the smaller for the bottom and sides.

When the osiers are used for ordinary work, they are taken whole; but for fine work, they are divided by an instrument consisting of two edge-tools set at right angles to each other, which quarter the rod longitudinally through the pith. These are next drawn through an implement resembling an ordinary spoke-shave, keeping the outer part of the split next to the wood while the pith is presented to the iron edge of the instrument; the split is further reduced and made regular in thickness by being drawn through a flat piece of steel having one cutting edge like a chisel; the flat is bent round so that the plain and cutting edges are made to approach or recede by means of set screws, regulating the thickness of the osier.

In basket-making, a number of rows are laid crosswise to form the start for the bottom, and are woven together by a spiral weft of wands, which pass alternately over and under the radial wands, to which others are added as the size increases; the wands are bent up to form the sides, and other rods are woven in and out between each of them, until the basket is raised to the intended hight. The edge or brim is

Fig. 593.

Basket-Making.

finished by turning down the projecting ends of the ribs, whereby the whole is firmly and compactly united. Handles are formed by forcing two or three osiers, sharpened at their ends and cut to the proper length, down the weaving of the sides close together, and they are pinned fast about two inches from the brim, so as to retain the handle in the proper position. The osiers are then bound or plaited, and the handle is finished.

Of late years much ingenuity has been exercised in devising forms of baskets for the carriage of fruit to market in packages of size proportioned to the character of the fruit. Osiers, splints, veneers, and paper have been employed. Some of these baskets are made frustum-shaped, so as to pack in nests for return; others have been made folding or collapsible; others of such cheap material and workmanship as to be sold with the fruit.

Veneer baskets are made with bails or handles, or simply as boxes. The parts are sometimes interwoven, but more often fastened by tacks or rivets.

2. (*Fortification.*) In field-works, a *gabion* or *corbeille* filled with earth and built into a parapet.

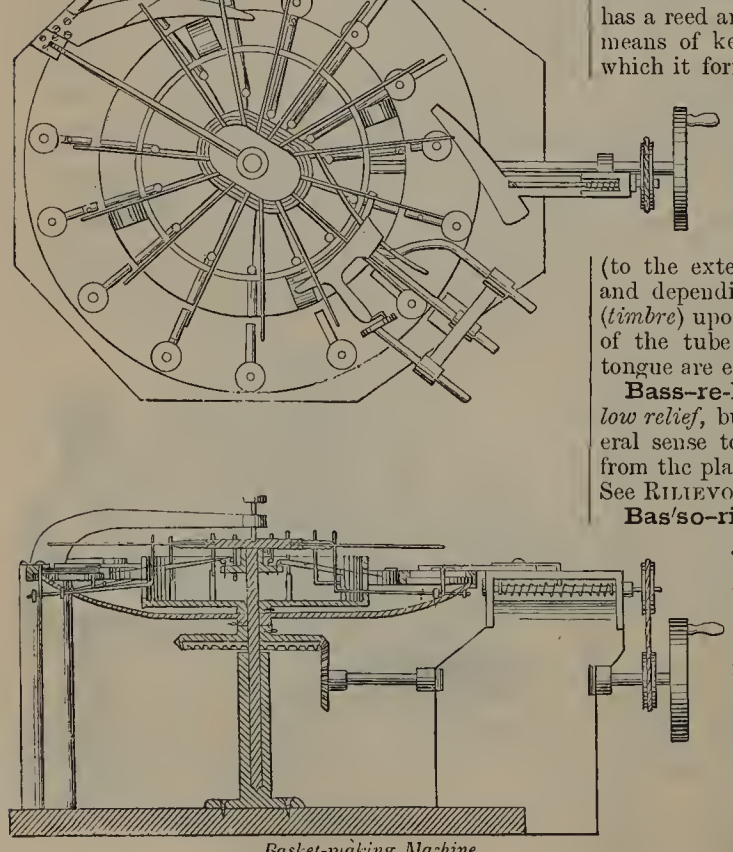
3. (*Hat-making.*) A wicker-work or wire screen of an oval shape, which collects the filaments of hair as they are lightly thrown on to it by the *bow*, which separates them from the bunch deposited on the bench. See BOWING.

Bas'ket-car'riage. (*Vehicles.*) A small vehicle with a wicker bed, and adapted to be drawn by ponies.

Bas'ket-grate. A fire-grate for burning coal, in which the bottom and one or more of the sides are made of bars, with intervening openings through which air is admitted and heat emitted.

Bas'ket-mak'ing Ma-chine'. A circular wooden bottom-piece with radially projecting basket-strips is attached to the end of a rotating shaft, and during the rotation of the bottom and radial strips, a filling-carrying device having a vibratory motion passes over and under the radial strips, and leaves the filling carried by it, and this filling is laid in compactly by reed-like pieces. See patents for this class of machinery to F. H. Brown, Nos. 68,965, 69,309, 70,072, 70,160, 70,318.

Fig. 594.



Basket-making Machine.

In the example, the skeleton of a top or bottom is clamped to the shaft by set screws. The end of the filling is fed through the apron. Motion is applied to the driving-shaft which rotates the skeleton. The pad of the apron is vibrated by the action of the eccentric wheel that rests upon the ring, causing the rods to vibrate alternately above and below the filling, which is introduced between them.

Bas'ket-work. (*Fortification.*) Work involving the interweaving of withes and stakes. Such as *wicker-work*, *randing*, *wattling*, *waling-gabions*, *fascines*, *hurdles*, etc.

Ba'son. (*Hat-making.*) A triangular metallic plate upon which a covering of fur is laid and felted to make a conical napping, or *pull-over* for a hat-body. The same as BASIN.

Bas'set. (*Mining Engineering.*) The *outcrop* or emergence of a stratum or seam at the surface.

Bas'set-horn. (*Music.*) A wind instrument resembling the clarinet in tone and manipulation, but larger. It is seldom employed in the orchestra, except in the execution of a few special pieces. It is believed to have been invented at Papan, about 1770, and afterwards perfected by Lotz, of Presburg.

Bas-sette'. (*Music.*) A small bass-viol.

Bass-horn. (*Music.*) A wind instrument of deeper tone than the bassoon.

Bas-soon'. (*Music.*) *a.* A musical wind instrument made of wood, and capable of being divided near the middle, so that the two parts may be of a more convenient length for carriage. The bassoon has a reed and curved mouth-piece, and is played by means of keys and finger-holes like the clarinet, to which it forms the bass. Its compass is three octaves, from double A in the bass, to A in the second space of the treble, and its designation generally is the F or bass clef, yet in the higher passages, for the more convenient arrangement of the notes, the alto or tenor clef is often used.

b. A reed-pipe stop in an organ, tuned (to the extent of its compass) with *open* diapason, and depending for the peculiar quality of its tone (*timbre*) upon the particular shape and proportions of the tube through which the vibrations of the tongue are emitted. See STOP.

Bass-re-lief'. (*Sculpture.*) Strictly speaking, *low relief*, but frequently used in a somewhat general sense to indicate the prominence of sculpture from the plane surface to which it remains attached. See RILIEVO.

Bas'so-ri'li-e'vo. (*Sculpture.*) The slight projection of a sculptured object from the plane surface, as in the case of the figures on medals, coins, friezes, etc.; called, also, *low-relief*. See RILIEVO.

Bass-vi'ol. (*Music.*) A stringed musical instrument resembling a violin, but larger, and having a graver tone. It is held in an upright position when played, the butt-end resting on the floor or some object but little elevated above it. The instrument now generally known as the bass-viol is, in fact, the violoncello.

Bast. A rope or cord made of the bark of the lime-tree, bass-wood, or linden; also the bark made into ropes and mats.

Bas'tard File. One of a grade between the *rough* and the *smooth*, in respect of the relative prominence and coarseness of the teeth.

The order is as follows: —

Rough.	Second-cut.
Middle-cut.	Smooth.
Bastard.	Dead-smooth.

The angle of the chisel in cutting the bastard file is about 10° from the perpendicular.

The number of cuts to the inch varies with the length of the file in inches.

Inches . .	4	6	8	12	16	20
Cuts . . .	76	64	56	48	44	34

Bas'tard Stuc'co. The finishing coat of plastering when prepared for paint.

Bas'tard Type. (*Printing.*) Type with a face larger or smaller than that usual to a body of given size; as, bourgeois on a brevier body.

Bas'tard Wheel. A flat bevel-wheel, or one which is a near approach to a spur-wheel.

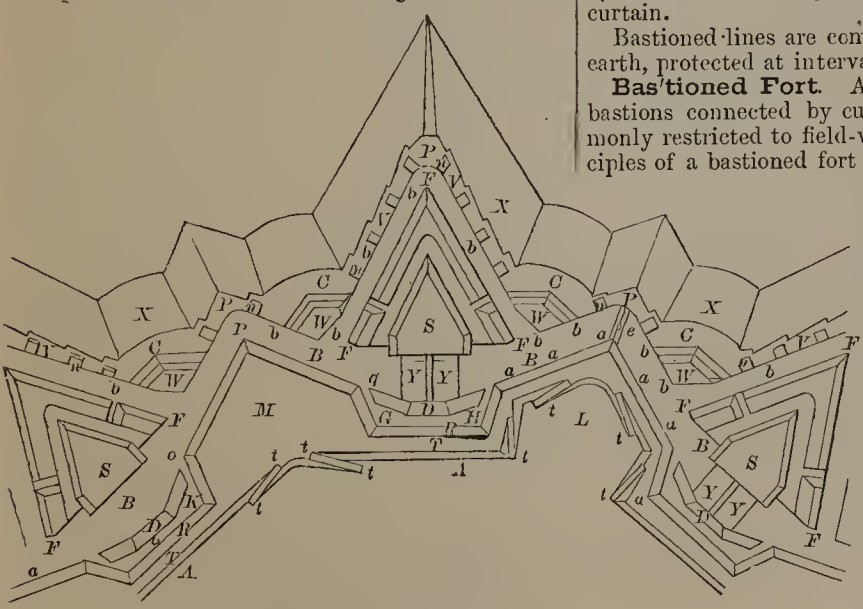
Bas-ter'na. (*Vehicle.*) The *basterna* of the Romans was a litter or species of sedan, carried by two mules, differing from the *lectica* in that the latter was borne by slaves. The name is derived from a people of the Carpathian Mountains, and was afterwards applied to a species of ox-cart or wagon used by the early kings of France.

The name survives in a modern European carriage.

Bast'ing-ma-chine'. A sewing-machine making the *running* stitch, and used in *basting* together the ends of pieces of cotton cloth, in order to form them into a continuous length for convenient feeding and handling during the operations of *washing*, *bleaching*, *singeing*, *printing*, *dyeing*, etc.

Bas'tion. (*Fortification.*) A projecting portion of the main inclosure of a fortification, consisting of two faces and two flanks, sometimes single or *detached*, but usually arranged on the angles of the fortification, and connected by a retired part called a *curtain*. In field-works, a series of bastions, formed at the angles of a square or pentagon, and thus connected with an exterior ditch, and sometimes a glacis, frequently comprise the whole system of defence; but in fortifications of a permanent character these are surrounded by outworks, and the number of bastions may be increased indefinitely, the polygon forming the basis of the works being adapted to the shape and capacity of the place to be defended.

Fig. 595.



Bastion.

Fig. 595 is a plan of two bastions (*M L*) connected by a curtain with outworks, as arranged on the modern system.

The various parts not particularly described here may be found under their respective alphabetical heads.

A. Interior slope.
T. Terreplein of rampart.
R. Parapet of rampart.
A T R. Rampart.
a. Scarp.
M. Full bastion.
L. Empty bastion.
p q. Face of bastion.
q G. Flank of bastion.
K o p q G. Outline of bastion.
G H. Curtain.
t. Ramps.
B. Ditch.
D. Tenaille.
Y. Caponniere.
e. Batardeau.
F F F. Ravelin.
S. Redoubt in ravelin.
b. Counterscarp.
n. Traverses in covered way.
C. Reëntering places of arms.
W. Redoubt in places of arms.
P. Salient places of arms.
V. Covered way.
X. Glacis.

A *hollow* bastion is one in which the *terreplein* is not continued to the rear beyond a certain distance, at which a farther descent occurs.

A *full* bastion incloses ground which is even with the rampart.

An *empty* bastion has a *terreplein* adjacent to the parapet, and the middle portion is much lower.

A bastion is said to be *composed* when two sides of the interior polygon are very unequal.

A *detached* bastion is separated from the inclosure by a ditch about its gorge, and not connected by a curtain.

Bastioned lines are composed of long parapets of earth, protected at intervals by bastions. See Line.

Bas'tioned Fort. A fort having two or more bastions connected by curtains. The term is commonly restricted to field-works. The essential principles of a bastioned fort are, that it is constructed so that the most prominent part of each salient is on a line bisecting the angle of a polygon; the *flanks* are arranged perpendicularly to the face of the opposite bastions, so as to obtain a raking fire within easy musket-range.

Bat. 1. A mallet.

2. A club for striking a ball in various plays; as, base-ball, cricket, croquet, etc.

3. A rammer used by founders.

4. (*Fiber.*) *a*. Clean cot-

ton in loose and evenly spread condition. The product of the batting-machine, in which the cotton is *scutched*, *blown*, and delivered in an even continuous wad, which, when wound on a roller or axis, forms a *lap* and is ready for *carding*.

b. A scutching or beating sword for hemp or flax.

5. (*Plumbing.*) A plumber's tool, made of beech, about eighteen inches long, and used for dressing and flatting sheet-lead.

6. (*Hat-making.*) *a*. One or more slivers of carded wool, or a body of blown fur. The subsequent processes are *shrinking* and *hardening*; the first by immersion in hot water, the latter by pressure and rubbing. Felting succeeds.

Web, *lap*, *sheet*, and *sliver* are synonymes in this connection.

b. In hand-work, a bat may be said to be a light assemblage of felting-hair gathered by the bow. It is compacted by pressure of the hands on a piece of leather called the *hardening-skin*, and by rubbing.

7. A half or other portion of a brick large enough to be worked into a wall.

Bat'ar-da'te. (*Nautical.*) A square-stemmed rowing-galley.

Bat'ar-deau'. 1. (*Fortification.*) A wall across the ditch to retain the water in that part of a ditch requiring to be inundated. Its crest is too narrow to afford a passage for the enemy.

2. (*Engineering.*) A coffer-dam, or case of piling without a bottom, for building the piers of a bridge. See COFFER-DAM.

Bat-bolt. (*Machinery.*) A bolt barbed or jagged at its *butt* or *tang*, to retain it within an object cast or solidified about it.

Batch. A lot of prepared materials or articles, suitable in quantity for once charging a pot, furnace, or oven.

1. (*Glass.*) The *frit* of a glass-maker compounded and sifted for use, ready for the *glass-pot* or crucible.

2. A lot of dough or unbaked loaves.

3. (*Mining.*) A certain quantity of ore sent from a mine to the surface by a couple of men.

Bate. (*Leather.*) The alkaline solution employed in the preparation of hides, after liming and before tanning, to remove or neutralize the lime. See BATING.

Ba-teau'. (*Nautical.*) *a*. A flat-bottom boat, used in navigation and propelled by oars or by poles.

b. A *ponton* of a floating bridge.

Bath. 1. A vessel in which the whole or a part of the person may be washed or bathed.

2. A house or place where such conveniences are provided.

3. A tank containing a liquid for galvanic or electro-metallurgic purposes.

4. A vessel containing a fluid metal or heated composition, as a lead-bath or sand-bath.

Baths were long used in Oriental countries, and traveled by the route of Egypt to Greece. Homer mentions the use of the bath as an old custom. From Greece they reached Rome, imported, as it is said, by Agrippa. The thermæ (*hot baths*) were very splendid, and adorned for a people who spent much leisure among the baths and their voluptuous accessories. The marble group of Laocoön was found in 1506 in the Baths of Titus, erected about A. D. 80; and the Farnese Hercules in the Baths of Caracalla, erected A. D. 217.

A rollicking Greek thus writes: —

"And lately baths, too, have been introduced, — things which formerly men would not have permitted to exist inside a city. And Antiphanes points out their injurious character: —

> 'Plague take the bath! just see the plight
> In which the thing has left me;
> It seems t' have boil'd me up, and quite
> Of strength and nerve bereft me.
> Don't touch me! Curst was he who taught a
> Man to soak in boiling water!'
>
> *Athenæus*, Epit. B. I. 32."

Homer, however, mentions another set, who

> "to the polished marble bath repair,
> Anoint with fresh perfumes their flowing hair,
> And seek the banquet hall."
>
> *Iliad.*

At one period there are said to have been more than 800 of these establishments in Rome, many of them doubtless of the smaller class, founded by private individuals. The erection of baths was one of the principal means by which many of the emperors endeavored to obtain fame and popularity. Nearly all these structures have yielded to the ravages of time, but sufficient remains are left to afford an idea of their general construction and arrangement.

The Baths of Caracalla were probably the most magnificent structure that adorned the ancient capital of the world; they occupied a quadrangle of 1,011 by 1,080 feet. The entrance was decorated by a portico composed of two stories of arcades, one above the other, erected upon half-columns, Ionic below and Doric above. Some of the finest statues of antiquity have been found within these ruins, giving an idea of their original magnificence.

These, like other structures of the kind erected by the Romans, were heated by stoves, and had arrangements for affording three different kinds of baths, cold, tepid, and warm, according to the taste or requirements of the bather.

For a piece of money equivalent to about half a cent any Roman citizen could procure the advantages of one of these baths, which were accessible alike to the rich and the poor.

The buildings were illuminated at night by lamps and candelabræ, the light of which was, according to Sencca, thrown on crystal balls placed in the vaulting or on the walls, so as to produce the most dazzling reflection. Glass was introduced in the time of Pliny, who calls it *a modern invention*. He was mistaken.

Remains of baths have been found in all countries where the Roman power extended. At Chester, England, among the ruins of a bath were found bricks stamped with the impression LEG XX, leading to the inference that the structure had been erected by the 20th Roman legion, surnamed the Victorious.

Those of Pompeii are still in a wonderful state of preservation.

In one of the baths of Rome, the basin was found to be coated with a cement so hard that it was impossible to dissolve it sufficiently to analyze its substance. It was a Roman palm (about three inches) thick, and capable of resisting not alone the heat of the water, but the action of any heat whatever.

The Roman bath had six principal apartments: —

1. The Apodyterium, appropriated to undressing, had shelves all round, on which to place the clothes, and had attendants to take charge of them.

2. The Frigidarium, or cold bath.

3. The Tepidarium, situated between the Frigidarium and the warm bath, and having a medium temperature.

4. The Caldarium, heated by the *dry* heat of a stove; the Laconicum. Here the bathers sweated.

5. The Balneum, or warm bath.

6. The Eleothesium; an apartment heated by the Hypocaustum, or underground furnace. Here the oils and perfumes were applied.

A *douche* bath is one in which the water is driven

or dropped forcibly upon the person or the part affected.

An *earth* bath is one in which the patient is covered with warm sand.

The names of other baths are sufficiently descriptive without detailed description under this general head.

Air-bath.	Shower-bath.
Electro-galvanic bath.	Sitz-bath.
Medicated bath.	Steam-bath.
Mercurial bath.	Turkish bath.
Russian bath.	Vapor-bath.

(*Photography.*) A solution in which plates or papers are immersed or floated; or the vessel holding said solution. Baths are known as *sensitizing* (the nitrate of silver bath), *fixing*, *toning*, or *washing*. They are of various forms, horizontal or vertical; the materials are glass, porcelain, or hard rubber.

Bath-brick. A fine silicious material, found in the vicinity of Bath, England, compacted into the form of bricks, and used as an abradant.

Bath-chair. (*Vehicle.*) A small hand-carriage with a hood. So called from the city of Bath, England, whose mineral waters are much frequented by invalids, and where the vehicle seems to have originated. For the legends of Bath, see Pickwick and the History of Prince Bladud.

Bath-fur'nace. A furnace for heating the water supplied to a bath.

Bath-heat'er. An apparatus for heating the water in a bath. It may consist of a pipe which connects with the upper and lower parts of the bathing-tub, and has a middle coil which traverses a furnace.

Bath'ing-ma-chine'. A portable room on wheels, for the convenience of bathers. It is run down into the water, so that the person is not exposed on the beach between the untiring-room and the water.

Bath'ing-tub. A tub or tank for bathing purposes; usually of elongated form, to permit the bather to assume a recumbent posture. The sitz or hip bath is like a deep-seated chair, and the water covers the person from the waist to the knees.

Bath-met'al. A brass for cheap jewelry, composed of, brass, 32; zinc, 9.

Bath-note. A folded writing-paper, 8½ by 14 inches.

Ba-thom'e-ter. (*Nautical.*) A measurer of depth. A *sounding apparatus*. The devices consist —

1. Of the common deep-sea lead and line.

2. Of devices for detaching the sinker on reaching bottom, enabling an attached tube to be drawn up separately, so as to secure a specimen from the bottom.

3. Of a weight within which a line is coiled to avoid friction in descending.

4. Of a sphere or spheres containing mercury, which the pressure at great depths forces into a tube or gage graduated so as to record the depth attained.

5. Of a spiral vane actuating a train of clock-work which registers the number of revolutions made by the vane, and thus indicates the depth. See SOUNDING APPARATUS.

Bath-stone. (*Masonry.*) An English building-stone of the oölitic formation.

Bat'ing. (*Leather Manufacture.*) The operation of steeping hides and skins in an alkaline solution consisting of the dung of chickens, pigeons, dogs, etc.

In this they remain six or eight days, according to the temperature of the *bate* and the thickness of the hide.

The *bating* follows the *liming* or unhairing solution, and the object of the former is to neutralize the lime and render the leather pliable.

Dog's dung (*album Græcum*) was formerly and is still applied; the ammonia probably being the active agent.

Sheep-skins are bated in bran-water.

The bating forms a chemical combination with the lime, the ammoniacal chloride parting with its chlorine to form the chloride of lime, which is readily dissolved in water.

MACBRIDE, in 1774, showed the property possessed by hydrochloric acid of dissolving the lime in the manner accomplished by the *bate*.

TURNBULL used sugar in the proportion of four or five pounds of cane-sugar or molasses to seventy gallons of water. This formed a soluble saccharate of lime.

WARRINGTON, 1841, employed carbonate of ammonia.

Ba-tiste'. (*Fabric.*) *a.* A very fine, white, thick linen cloth or cambric. Made of a fine quality of white flax grown in the South of France, and called *ramé*. (Not the *ramie*.)

b. An East India goods of similar quality.

Bat-print'ing. (*Porcelain.*) One mode of *porcelain printing*; the other is termed PRESS-PRINTING (which see). The former is printed on *glazed ware*, the latter on the *biscuit*.

In *bat-printing* the lines of the engraving are fine, and the impression is taken in linseed-oil on a thin slab of gelatine cut to the size. The oil having been transferred to the glazed ware by pressing the gelatine against it, is next dusted with the metallic color by means of cotton-wool. The color is melted and fixed in an *enamel-kiln*.

Bat's-wing Burn'er. (*Gas.*) A form of gas-burner in which gas issues at a slit so proportioned as to give to the flame the shape of a bat's wing.

Batt. The hat-maker's term for the basis of the *skin*, or bowed materials of a hat. *Bat*.

Bat'ten. A strip of wood or a scantling, as may be required, for various purposes.

1. (*Carpentry.*) *a.* A cleat or bar nailed transversely on a structure of jointed planks, such as a door or shutter, to prevent warping and preserve the relative position of the parts.

A *batten* door is formed of planks laid side by side, and secured together by slats fastened across them, without exterior framing.

b. A board 2 to 7 inches wide, and from ⅝ to 2 inches thick. (English practice.)

c. In *furring*, scantling secured to brick walls to form a foundation on which plastering lath is laid.

d. A strip nailed to the rafters, to which slats are nailed.

2. (*Plastering.*) A batten is placed at exposed corners so as to be flush with the worked surface of plaster, and resist abrasion or blows. Called also an *angle-staff*.

3. (*Cotton.*) A web or bat of fibers.

4. (*Weaving.*) The beam which forces up the weft. *Lay* or *lathe*.

5. (*Nautical.*) *a.* One of the strips placed around the hatches, to keep down the tarpaulin which covers them.

b. Strips tied around standing rigging to keep it from chafing.

Bat'ter. 1. (*Engineering.*) The backward slope of a wall, to enable it to withstand an outward thrust, as of a bank which it retains. *Retaining* and *breast walls batter* towards the bank. See BREAST-WALL.

2. (*Forging.*) To spread metal outwardly by hammering on the end. The impact upsets the bar or rod, and extends it outwardly.

3. (*Pottery.*) A plaster mallet used to flatten out a lump of clay which is to be laid and formed upon the *whirling-table*,

The batting is done upon a *batting-block* of wet plaster.

Bat'ter-ing-gun. (*Ordnance.*) One of heavy caliber, specifically adapted for demolishing works. Examples: the 18 and 24 pounder smooth-bore, and the 4½-inch rifled gun of the United States service.

Bat'ter-ing-ram. An implement, used before the invention of gunpowder, for making breaches in the walls of fortified places. It consisted of a long pole or beam, with an iron head, suspended between uprights. The head sometimes weighed a ton or more. The men who operated it were protected by the *testudo*, a movable shed with a curved roof, adapted to resist the stones, etc., thrown on it by the besieged.

This machine is incorrectly stated to have been invented by Artemon, a Lacedemonian. It was employed by Pericles, about 441 B. C. The pole was from 80 to 120 feet long, and suspended by cords on which it oscillated, being retracted by the united efforts of a number of men, who pulled the cords and then allowed the spar to swing forward and bring its armed head against the masonry of the besieged fortress. Its effects were sought to be avoided by lowering down bags which acted as fenders to deaden the blow, by burning the framework, or by hurling missiles at the operators. See descriptions of Roman military engines, and Josephus.

Assyrian antiquities upset the Greek claim of first invention. Battering-rams are shown in the sculptures of Nimroud. The machine is worked from within, upsetting the walls by dislodging the stones. The *testudo* was made of wicker-work, and ran upon six wheels.

The battering-ram is mentioned by the prophet Ezekiel (iv. 2 and xxi. 22) about 590 B. C.

Bat'ter-ing Plumb-rule. (*Engineering.*) An instrument for leveling sloping work. The sides are cut to the required angle with the central line, over which the plummet hangs.

Bat'ter-ing-rule. (*Engineering.*) A rule or templet by which the *batter* or slope of a *retaining* or *breast* wall is regulated in building.

Bat'ter-ing-train. (*Ordnance.*) A train of heavy ordnance for siege operations.

Bat'ter-lev'el. (*Engineering.*) An instrument for measuring the angle of a slope. See CLINOMETER.

Bat'ter-y. A number of objects or devices in position; as of *guns*, *plates*, *kettles*, etc.

A position or place in which objects are mounted; as a *sunken*, *barbette*, or *casemate* battery.

Barbette battery.	Grove battery.
Battery forge.	Gun battery.
Battery gun.	Half-sunken battery.
Breeching battery.	Hat-maker's battery.
Bunsen battery.	Leclanche battery.
Callaud battery.	Leyden battery.
Carbon battery.	Magneto-electric battery.
Casemate battery.	Masked battery.
Covered battery.	Mountain battery.
Cross-fire battery.	Open battery.
Daniell's battery.	Ricochet battery.
Double-fluid battery.	Siege battery.
Electric battery.	Single-fluid battery.
Electro-magnetic battery.	Smee battery.
Elevated battery.	Stamp battery.
En-echarpe battery.	Submarine battery.
Enfilading battery.	Sugar-kettle battery.
En-revers battery.	Sunken battery.
Field battery.	Thermo-electric battery.
Floating battery.	Voltaic battery.
Galvanic battery.	

Many of these are described under their alphabetical heads.

1. (*Fortification.*) *a. Barbette battery;* the guns are elevated to fire over the top of the parapet, and not through embrasures.

b. Breeching battery; one employed in making a practicable breach in an enemy's works.

c. Blinded battery; one masked or hidden till the time comes to make it effective.

d. Casemated battery; one firing through embrasures in a bomb-proof chamber.

e. Cavalier battery; one mounted on an elevated interior work.

f. Counter battery; one on the crest of the glacis, to cover the storming party.

g. Direct battery; one firing perpendicularly upon a work.

h. Enfilading battery; one which flanks a work, entrenched line, or line of attack.

i. Fixed battery; one permanently established, as in a fortress.

j. Floating battery; one on a raft or ship.

k. Inclined battery; one on a sloping ground.

l. Indented battery; one with indentations or occasional notches which command the face.

m. Joint battery; one of two which form supports to each other.

n. Leveled battery; one in which the interior has the natural level, the parapet being gained by earth from the ditch.

o. Masked battery; one artificially concealed.

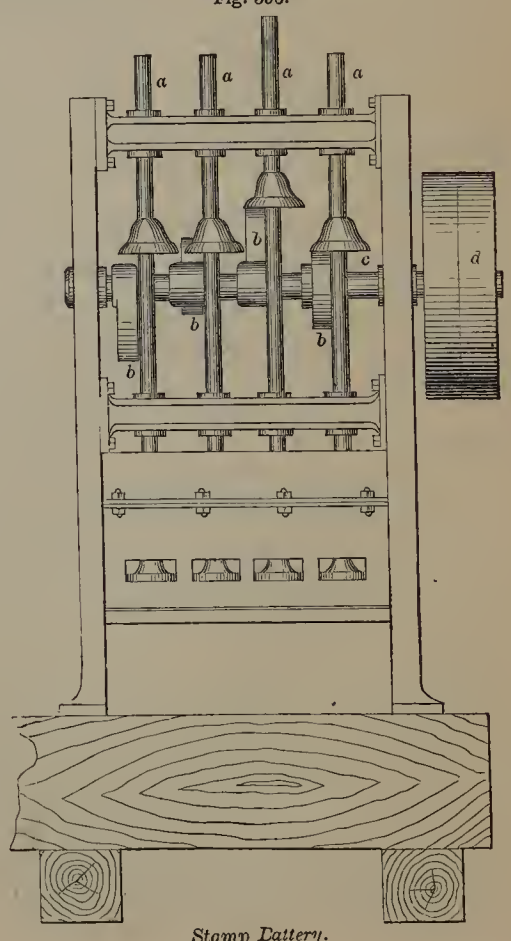
p. Oblique battery; one to deliver an enfilading fire.

q. Open battery; one of field artillery.

r. Ricochet battery; one delivering its fire with small charges, the missile rolling and popping along the ground.

s. Sunken battery; the included space of which is excavated.

Fig. 596.



Stamp Battery.

GATLING'S BATTERY-GUN.

EGYPTIAN SERVICE.

PLATE VI.

See page 249.

2. (*Metallurgy.*) A series of *stamps* operated by one motive power, for crushing ores containing the precious metals.

The stamps *a* (four in the series shown) are raised consecutively by the cams *b* on the shaft *c*, to which motion is imparted by a belt on the pulley *d*.

3. A number of connected Leyden jars, adapted for coincident charging and discharging. See ELECTRIC BATTERY.

4. An apparatus for generating galvanic electricity. See GALVANIC BATTERY.

5. A vessel with sides protected to withstand cannon projectiles, and pierced for heavy guns. Distinguished from an ordinary war vessel by its comparatively imperfect capacity for navigating in all waters and weathers. A floating battery.

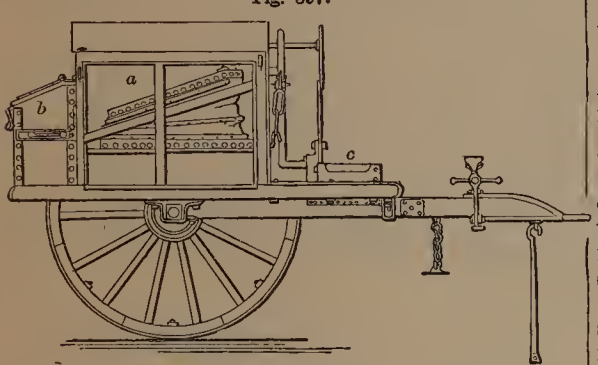
6. (*Nautical.*) The guns mounted on each deck of a ship of war; as the *main-deck*, *lower-deck*, and *spar-deck* batteries.

Bat'ter-y-brush. A small brush, shaped like a hair-brush, used for cleaning or brushing off oxides formed on zinc, and for evenly distributing the mercury or amalgam over the zinc.

Bat'ter-y Com'mu-ta'tor. (*Telegraphy.*) An apparatus by which the strength of a current may be altered, so that one third, two thirds, or the whole of the elements may be brought into service by changing the place of a contact-peg. See Sabine, p. 104.

Bat'ter-y-forge. A traveling forge which accompanies a field battery. The body is constructed like that of a caisson, except that in place of the two ammunition-chests it has a *bellows-house a*. This

Fig. 597.



Battery-Forge.

contains the bellows, and has a space partitioned off for iron and steel. In the rear is a box *b*, to hold 250 pounds of bituminous coal, and in front is the fireplace *c*, upon which the anvil is placed in traveling. An upright plate of strong sheet-iron is interposed between the fireplace and the front of the bellows-house. In the limber-chest are contained a set of blacksmith's and farrier's tools packed in four boxes (for field batteries). In the United States service battery-forges are divided into two classes, A and B. One of the former accompanies each field battery, and contains a forge as well as the blacksmith's and farrier's tools, iron and steel, horseshoes, and spare parts necessary for making the more ordinary repairs to the iron-work of the battery.

Forge B, which is precisely alike in size and construction, contains nearly the same tools and stores as forge A, but has, in addition, certain articles and spare parts which are less likely to become broken or worn out in service. It remains in the rear with the field and siege train.

Bat'ter-y-gun. A gun having a capacity for firing a number of shots consecutively or simultaneously, without stopping to reload. There are a number of varieties.

1. A piece of ordnance having a number of load-chambers attached to a vertical axis, and consecutively presented at the rear of a cannon-bore. As each takes its place at the breech, it is advanced into the bore and locked before firing. (HARDY, 1862; DODGE, 1856.)

2. A chambered breech-piece, revolving in a vertical plane, and presenting its chambers consecutively at the open rear of the barrel, which is common to all the chambers. The principle of construction is that of the revolving chambered pistol. (HEDRICK, 1870.) See also FIRE-ARMS, where PUCKLE'S Revolving Battery Gun, English Patent, 1718, is described and figured.

3. A number of parallel barrels arranged in rank, and having connected vents for intercommunication of fire. (TOWNSEND, 1871.) The infernal machine of Fieschi, which he fired on Louis Philippe, was a row of barrels clinched to a frame, and had a train of powder which was laid over all the vents in succession, like the row of barrels in a proving-house.

The Requa battery consists of 25 rifles, each 24 inches long, mounted in a horizontal plane upon a field-carriage. It is breech-loading, the cartridges being forced into the chambers by a sliding bar worked by two levers. By a lever beneath the frame the barrels may be diverged, so as to scatter the balls 120 yards in a distance of 1,000 yards.

The weight of the battery-gun used at Charleston, S. C., was 1,382 pounds. Served by three men, it fired 7 volleys, or 175 shots, per minute. Its effective range was 1,300 yards.

4. Forms of many-barreled cannon, revolving on a vertical axis, the pieces being muzzle-loaded. (MILBURN, 1866. Divergent, NATCHER, 1864.)

5. A cluster of rotating barrels, consecutively loaded and fired by automatic action. (GATLING, 1861–65.) This will have a longer description presently.

6. A cluster of barrels, in whose rear is placed a chambered plate, each of whose chambers corresponds to one of the cluster of barrels, against whose rear it is locked before firing. The MITRAILLEUR (which see).

7. A number of chambered blocks brought consecutively to the positions for loading, and then for firing, through a group of barrels equal in number to the number of chambers. (TAYLOR, 1871.)

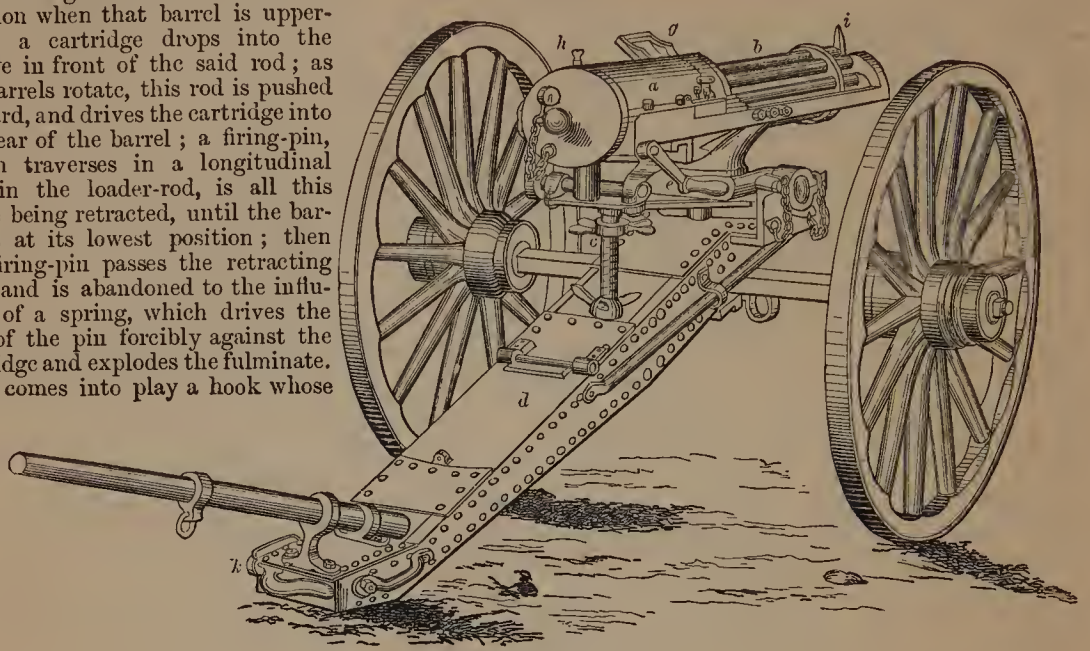
The Gatling gun has a revolving cluster of parallel barrels. In the rear of each barrel, and rotating therewith, is its own loading, firing, and spent-cartridge-shell-retracting mechanism. All these parts are rigidly secured upon an axial shaft, which is revolved by means of bevel gearing and a crank, as shown in Fig. 598, and also in Fig. 599, which are respectively rear and front views of the gun mounted. In the rear of the cluster of barrels *b* is a stationary cylinder *a*, within which are the loading plungers, the firing-pin, and the cartridge-retractor.

Each of these parts moves horizontally and in line with the barrel to which it appertains, the motion being attained by the pressure of lugs on the moving mechanism against stationary cam-rings in the cylinder as the cluster of parts revolves. The ammunition is fed in at the hopper *g*; or, as in an improved form shown in the full-page engraving opposite to page 250, the ammunition is contained in a feed-drum which is placed above the hopper, and delivers its cartridges one at a time from its successive rows. Its capacity is four hundred cartridges, and these may all be fired in one minute.

As the cluster of barrels revolves, the operative

mechanism in the rear of each barrel comes under the influence of the cam-rings in the interior of the cylinder. The loading-rod of a given barrel being in the most retracted position when that barrel is uppermost, a cartridge drops into the groove in front of the said rod; as the barrels rotate, this rod is pushed forward, and drives the cartridge into the rear of the barrel; a firing-pin, which traverses in a longitudinal slot in the loader-rod, is all this while being retracted, until the barrel is at its lowest position; then the firing-pin passes the retracting cam, and is abandoned to the influence of a spring, which drives the end of the pin forcibly against the cartridge and explodes the fulminate. Now comes into play a hook whose shank runs parallel with the loader-rod, and withdraws the empty shell of the cartridge, which drops out of the machine. The barrel then takes its turn again above, and so the work proceeds.

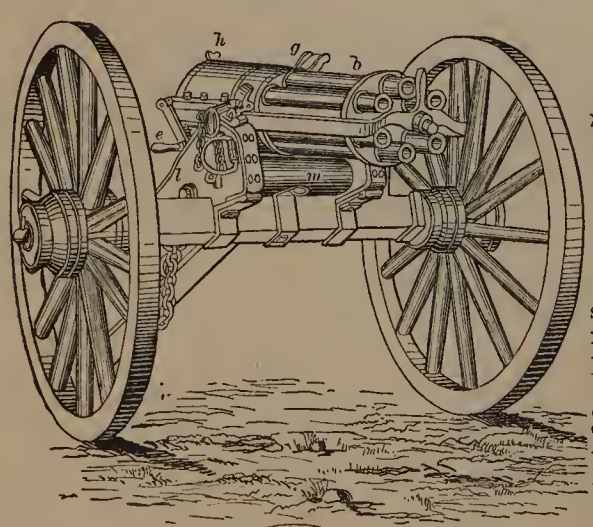
Fig. 598.



Gatling Gun (Rear View).

e is the working-crank, *c* the elevating-screw, *d* the trail, *k* the loop by which the trail is attached to the limber, *h i* are the back and front sights, *l* the cheeks of the carriage. In the view on the opposite page the Gatling gun is represented as adapted to various services: mounted on tripod, on carriage, on horse, on camel. The weight of the guns is 125, 300, 500, 600 pounds, according to size. The firing is always one shot at a time, and a number of shots equal to the number of barrels at each revolution of the crank. The recoil is practically nothing. Arrangement is made for horizontal adjustment to deliver a sweeping fire.

Fig. 599.



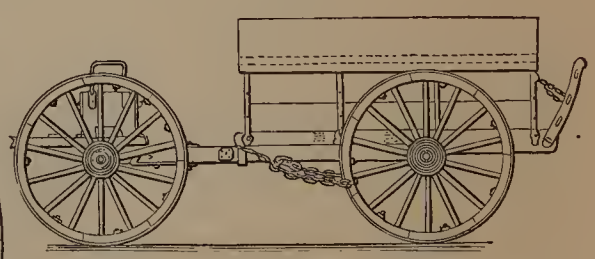
Gatling Gun (Front View.)

Bat'ter-y-head. (*Railroad Engineering.*) The end of an embankment under formation, over which the contents of the gravel-wagons are dumped.

Bat'ter-y-wag'on. A four-wheeled vehicle, expressly adapted for the purpose of transporting the tools and spare parts required for the repairs of a battery of artillery in the field; one is attached to each battery.

It has a body 98.8 inches long and 3 feet wide in the clear, and an arched wooden top, turning over on hinges like a trunk-lid. At its rear is a rack for forage. The wagon-body and the limber-chests carry spare parts for the carriages, harness, etc.; also harness-maker's tools, paint, oil, candles, axes, hatchets, picks, and miscellaneous tools.

Fig. 600.



Battery-Wagon.

In the United States service battery-wagons are designated, according to their contents, C and D. The former accompanies the field-battery in its evolutions, and is posted a short distance in the rear in time of action. It contains the tools, materials, and spare parts necessary to repair on the spot the smaller casualties most likely to occur to the wood-work and harness of the battery.

Battery-wagon D is precisely similar in construction, but contains a different set of stores and tools, such as armorer's tools and laboratory implements,

as well as such spare parts of gun-carriages as are less likely to require replacement.

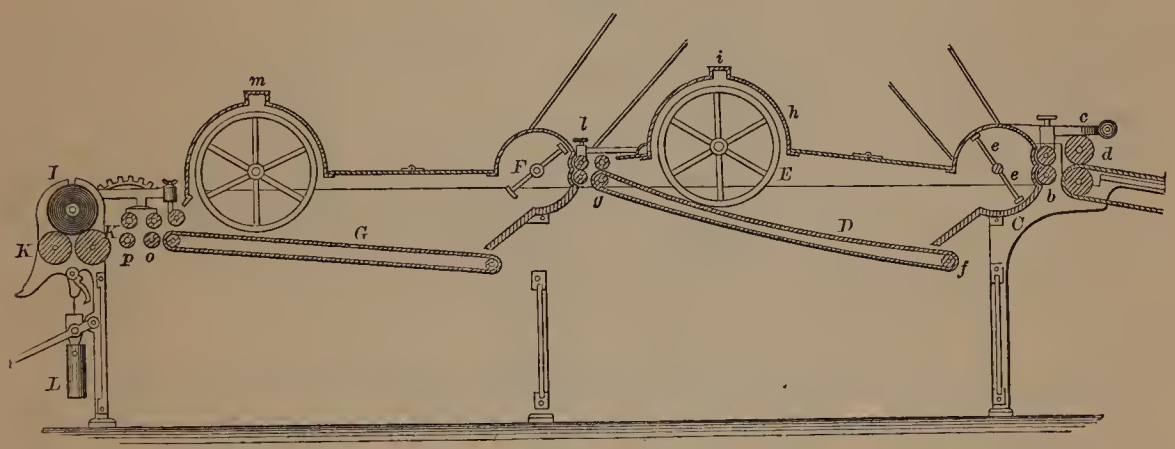
It remains with the vehicles of the field-train, and is only resorted to when the means afforded by wagon C are inadequate for the necessary repairs.

Bat'ting-block. (*Pottery.*) A block of wet plaster on which a dab of clay is flattened out by a *batter*, to prepare it for being placed on the *whirling-table*, where it is formed by a mold and templet into a piece of circular ware.

Bat'ting-ma-chine'. (*Fiber.*) A machine in which cotton partially loosened and cleaned by the *willowing-machine* (which see) is *scutched*, *blown*, and *lapped* so as to fit it for presentation in a soft, downy, and even wad to the carding-machine.

As a preliminary process, the cotton is carefully weighed, a given quantity being distributed on a certain surface of the slatted feed-apron, which has occasional black slats in order to mark certain areas. The cotton, being spread evenly over the given area, passes into the throat of the machine under the compressing-roller *d*, and then between the feed-rollers *b*, which are pressed together by a weight acting upon a lever *c*, which acts upon the brasses above the rollers. Passing the fluted cylinders *b*, the cotton is immediately exposed to the first scutching-beater, which consists of two flat bars *e e* fixed at right angles upon a revolving shaft, so as to strike upon the cotton as it issues from between the feed-rollers. The *scutcher* makes 2,000 revolutions per minute in near proximity to the grated concave *C*, through which dirt escapes. The cotton is wafted on to a traversing slatted apron *D*, which revolves on the rollers *f g*, passing beneath a revolving cage-cylinder *E*, inclosed by the cover *h*, in the top of which is a dust-duct *i*, in communication with a revolving fan, which exhausts the air from the interior

Fig 601.



Batting-Machine.

of the machine, and therewith withdraws the dust. The reticulated cylinder *E* allows the air and dust to pass, but retains the cotton fiber, which is pressed into a *bat* upon the apron *D*, and delivered to a second pair of feed-rollers *l*, when it is again exposed to a scutcher *F*, which acts similarly to the one before described. This scutcher has 2,200 revolutions per minute, and delivers the cotton to an apron *G*, which carries it beneath another reticulated, dust-withdrawing cylinder in communication with the air-exhaust duct *m*.

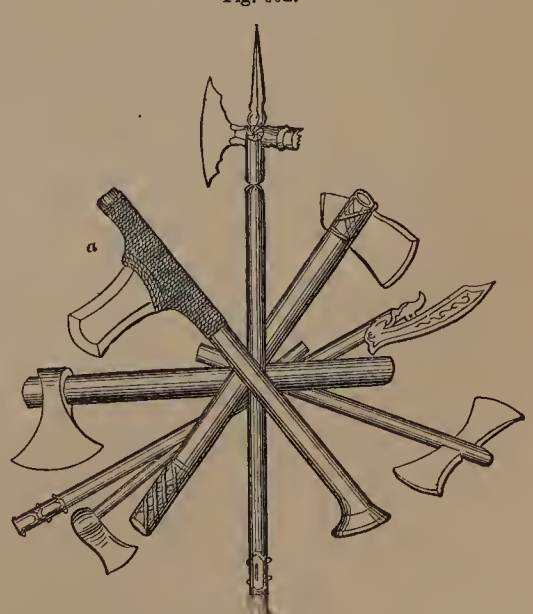
The cotton thence passes in a fleecy mass to the pressure-rollers *o p*, which deliver the compressed fleece to the cylinder whose axis is loaded by suspended weights *L*, which bear it down upon the carrying-rollers *K K*, whereby the fleece is condensed as it is wound. As the lap-cylinder *I* increases in diameter, the links rise, carrying the weights *L*, and when the *lap* has attained the required size, the main portion of the machine is thrown out of gear, while the twin rollers *p p* continue to revolve, and thus tear the bat apart in the middle between the pairs of rollers *o p*. The attendant then removes the lap, hooks up the weighting device, places another lap-cylinder in position, starts the machinery, restores the action of the weight, and guides the advanced edge of the bat around the cylinder. See COTTON-CLEANER.

Bat'ting-staff. An implement used by laundresses for beating linen in washing.

Bat'ti-tu'ra. The scales which fly off from metals while under the hammer.

Bat'tle-axe. This military weapon is of very remote antiquity, being made of stone before the discovery of metals. (See AXE.) It was used by the Sacæ, who formed a part of the forces of Xerxes.

Fig. 602.



Battle-Axes.

Brennus, the Gallic king, who captured Rome, was armed with a battle-axe, and in remote ages it appears to have been considered peculiarly as the weapon of an uncivilized people. It was, however, extensively employed during the Middle Ages, and was in use as late as the sixteenth century, when attempts were made to improve it by attaching a pistol to the handle.

a, battle-axe from Dr. Abbott's collection of Egyptian antiquities in New York; made of bronze, firmly bound to its original handle by means of slender interlaced thongs of leather. It was found at Thebes.

The other figures represent battle-axes, more or less rude, of the times known as the "Roman period" and the "Middle Ages."

Bat'tle-dore. 1. (*Glass-making.*) A flat wooden paddle, used in flatting glass while still plastic, as in making the flat bottoms of decanters, etc.

2. An instrument of play, having a handle and a flat surface, or palm, formed of a hoop, and stretched parchment covers. It is used in playing shuttlecock.

Bat'tle-ment. (*Architecture.*) An open or interrupted parapet on the roof of a building. A parapet with embrasures.

Bauge. (*Fabric.*) A French fabric made with thread spun upon coarse wool.

Bav'in. A fagot of brushwood, sometimes used as a fascine.

Baw'sin. Leather made from sheep-skin. (Fr. *basane.*)

Bay. 1. (*Architecture.*) One of the lights or compartments between mullion and mullion in the great windows of the pointed style.

2. (*Carpentry.*) A portion of a compound or framed floor included between two girders, or a girder and the wall.

a. A case-bay is between two girders.

b. A *tail-bay* is formed of common joists, where one end of each is framed into a girder and the other rests on a wall.

c. A portion of a wall included between pilasters or buttresses, or of a ceiling between the beams of the panels.

3. The term is also used in a compound form: —

a. A *bay of plastering;* between two screeds which regulate the working of the float.

b. A *bay of roofing;* the small rafters and their supporting purlins between two principal rafters.

c. A *bay of joists;* the joists between two binding-joists, or between two girders in a framed floor.

Hay-bay in a barn; a *sick-bay* on shipboard.

4. (*Ship.*) That part on each side between decks of a man-of-war which lies forward of the butts.

5. (*Bridging.*) The portion between two piers.

6. (*Mining.*) The space between two frames in a gallery.

7. (*Hydraulic Engineering.*) *a*. The head of a lock.

b. A compartment containing water for a wheel, as a *fore-bay*.

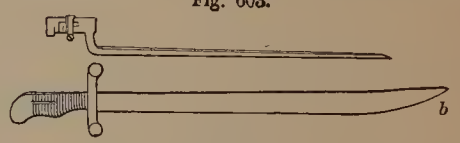
Bay-bolt. One with a barbed shank.

Bay'o-net. A piercing weapon, fixable on the muzzle-end of a fire-arm. They were originally made at Bayonne, in France, in the latter half of the seventeenth century, and used by that nation in the Netherlands in 1647. The weapon was introduced into the English army in 1672, and used at Killiecrankie, in Perthshire, where the forces of William of Orange, commanded by Mackay, were defeated by those of James II., under the command of Graham, of Claverhouse, 1689; and also at the battle of Marsaglia, 1693, "with great success against the enemy, unprepared for the encounter with so formidable a novelty."

The first known bayonet was a kind of long and slender rapier, with a wooden handle, or plug, which was inserted into the muzzle of the musket. Previous to this it had been customary to distribute musketeers among the pikemen, the two mutually supporting and assisting each other. The above-named arrangement for fixing the bayonet does not seem to have prevailed long, and was soon superseded by a slotted socket on the lower part of the bayonet, which slipped over the muzzle of the musket and was held in position by a stud on the barrel. The ring-bayonet was introduced in 1693, and the socket-bayonet in 1703. This form continued in use for about 150 years, an annular clasp and screw being added about 1842 in the United States service.

The "sword" bayonet *b* seems to be of very recent origin, having been first recognized in the United

Fig. 603.



Bayonets.

States army in 1856. Its utility as a weapon is very questionable. It is believed that this form of bayonet was first introduced in the French service among the Chasseurs de Vincennes, who used it in Algiers, in the Crimean campaign of 1854 – 55, and the Italian war of 1859.

It is secured to the rifle by a ring in the guard and a spring-catch in the hilt.

The *saw-bayonet*, having a sword edge and a saw back, is now being tested for the British arms. The *spade-bayonet* has also its advocates, it being intended to enable the soldier to intrench his position. The tendency seems to be to beat their spears into trowels and their swords into pruning-saws, but the peaceable intention is not apparent. See INTRENCHING TOOLS.

The bayonet-blade is forged under a trip-hammer, after which it is rolled to a proper form by sets of rollers adjusted to give it the required shape and taper. The socket is then forged, and the two portions welded together. It is next twice swaged by the "drop," then ground and polished; the former on a stone, and the latter on wheels bound with leather and covered with emery. The bayonet is rigidly gaged, and then tested by weight and by blow to determine its soundness and temper.

Bay'o-net-clasp. A movable ring of metal surrounding the socket of a bayonet, in order to strengthen the socket and render the bayonet less easily detachable.

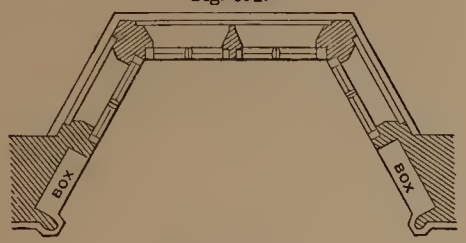
Bay'o-net-joint. A peculiar form of coupling, in which one circular piece, having a slot longitudinal for part of its length and transverse the remainder, is sleeved over another. The interior piece is provided with a stud which enters the slot, and, by turning, the two parts become locked so as to prevent withdrawal by a longitudinal movement.

Bay'o-net Scab'bard. The sheath in which the bayonet is placed. It has a loop at its upper part, called the *frog*, through which the waist-belt passes.

Bay-stall. (*Building.*) A fixed seat within a window-opening.

Bay-win'dow. (*Building.*) A *bow*-window; one projecting from the general surface of the house. It is usually of semi-polygonal shape, sometimes semicircular or semi-elliptical.

Fig. 604.



Bay-Window.

Bdel-lom'e-ter. A cupping-glass to which are attached an exhausting syringe and a scarificator.

Bea'con. A structure erected for the purpose of assisting navigatiou by pointing out those dangers which, owing to the difficulty and expense that would attend the placing of more efficient marks to serve by night as well as by day, are necessarily left without lights, or which, from the peculiarity of their position in passages too intricate for navigation by night, are considered sufficiently indicated by day-marks alone. They are generally placed on rocks or banks only which are dry at some period of the tide. On rocks in exposed situations beacons are sometimes of squared masonry, firmly joggled together; but in situations difficult of access, and where an uncompleted structure of masonry could not be safely left exposed to the storms of winter, an open framework of iron, firmly trussed, braced, and secured to the rock, is preferable. In less exposed situations, where the bottom is of rock, gravel, or hard sand, a conical beacon, composed of iron plates and partially filled with concrete, is sometimes employed.

In a comprehensive sense, a lighthouse is a *beacon;* but the term technically refers to day marks, or to night marks where cressets are employed.

A *sonorific beacon*, so called, is one provided with an apparatus for sounding an alarm. See FOG-ALARM.

Bead. 1. (*Carpentry.*) A small salient molding of semicircular section.

Fig. 605.

Beads.

a. Cock-bead.
b. Quirk-bead.
c. Bead-butt.
d. Bead-flush.
e. Double-quirked bead.

A small globular ornament, often occurring in a long series, forming a band or molding.

The strip on a sash-frame which forms a guide for the sash. The *beads* are known as the *inside, outside,* and *parting beads.*

2. (*Bookbinding.*) A roll on the headband of a book.

3. The proof of spirit, consisting in the appearance of the rising bubbles.

4. A perforated piece of glass, metal, or other material, adapted to be strung in a series, and used for the purpose of ornament or in devotion. This latter use came from Asia to Europe, and from the latter to America.

Glass beads originated with the Egyptians, — at least, such are the indications. One, in the possession of Captain Henvey, has a hieroglyphic inscription which shows its date to be about 1500 B. C. Glass bugles and beads for necklaces were much used by the Egyptians, and for a sort of network in the mummy-wrappings.

Beads strung in chaplets have long been in use for devotional purposes among Eastern nations, and are worn by the Chinese and Tartar Buddhists, as well as by the Turks and other Mohammedan nations. The Chinese rosary is composed of 108 beads of stones and coral, which are sometimes as large as pigeon's eggs. The use of beads in the Christian Church is of great antiquity. St. Augustine mentions them A. D. 366. Peter the Hermit had a series of 55 beads. Dominic de Guzman, A. D. 1202, introduced the rosary of 15 large and 150 small beads. Beads were used by the Druids in the time of Cæsar.

Beads are made of a great variety of materials: gold, diamond, amber, pearl, coral, jet, garnet, crystal, steel, paste, wood, glass, etc., much the greater proportion, however, being of the latter material. The manufacture is extensively carried on at different places in Europe, that of each place being characterized by some peculiarity in the style or manner of manufacture. Immense numbers are made at Birmingham, certain varieties of which are sold by thousands of dozens as dolls' eyes.

At Murano, near Venice, where great numbers are made, tubes of glass of various colors are drawn out to a great length and cut into very small pieces of uniform length, which are then put in a heap with a mixture of sand and wood ashes, and stirred with a spatula until the cavities become filled. The mixture is then transferred to an iron pan suspended over a moderate fire, and stirred until the cylindrical bits of glass assume a smooth rounded form. (See BEAD-FURNACE.) When removed from the fire, and their bores cleaned out, they constitute beads.

A very beautiful and costly sort of beads are made in imitation of pearls, from which the best qualities differ so slightly in appearance as to require an expert to detect the difference. The bead is blown into a thin bulb, and the pearly appearance produced by pouring into it a mixture of liquid ammonia mixed with the white matter from the scales of certain kinds of fish, as the bleak. The pearl matter is prepared by removing the scales from the lower part of the fish, washing them, and soaking them in water until the pearly film falls off and forms a sediment in the bottom of the vessel; this is dissolved in liquid ammonia and injected into the beads, so as to form a thin coating inside; after which the better kinds have melted white wax poured in, rendering them much more durable. Artificial pearls were invented by a Frenchman named Jaquin, in the time of Catherine de Medicis, and are principally manufactured in the department of the Seine, where great improvements have been made in the art; such as giving irregular forms to the large bulbs, to increase their resemblance to pearls, and exposing them for a short time to the vapor of hydrofluoric acid, so as to remove the glassy appearance of the exterior coating. Mucilage of gum-arabic is also used instead of wax, which increases the translucency, and is not liable to be melted by heat.

Beads of agate, carnelian, and allied stones are made in British India by breaking the stones into pieces of the required size, and chipping them with a hammer until rounded. They are then fixed in wooden clams, and partially polished by rubbing on a coarse, hard stone, after which they are similarly treated by being rubbed on a board covered with emery and lac. The polishing process is completed by placing a large number of them in a leathern bag partially filled with emery-dust and a fine powder derived from the stones themselves in drilling, and rolling the bag backwards and forwards for some ten or fifteen days by means of a thong passing around it and operated by two men seated at the opposite sides of a room. The holes are afterward drilled with a steel drill tipped with diamond dust.

Bead and Butt. (*Carpentry.*) Framing in which

the panels are flush, having beads stuck or run upon the two edges. See *c*, Fig. 605.

Bead and Quirk. A bead stuck on the edge of a piece of stuff flush with its surface. See *b*, Fig. 605.

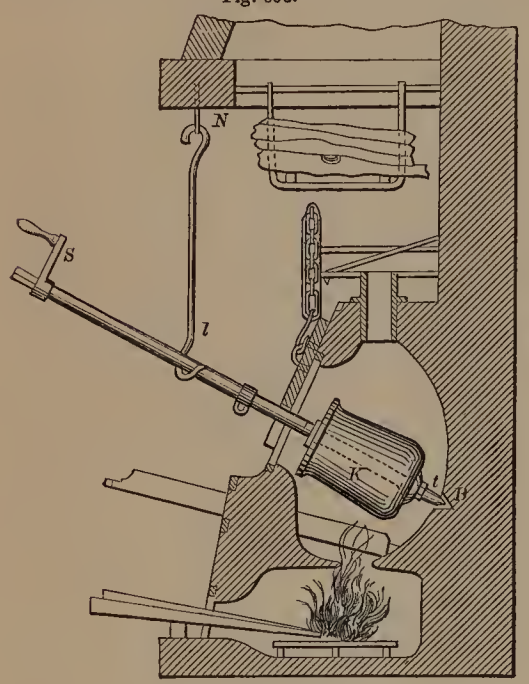
Bead-butt and Square-work. (*Carpentry.*) Framing with bead and butt on one side and square on the other; used in doors.

Bead'ed Wire. An ornamental wire having globular enlargements at regular intervals.

Bead'ed-work Lathe. See MILLED WORK; GAGE-LATHE.

Bead-fur'nace. (*Glass.*) A furnace in which glass beads are rounded after the cylinders have been cut to the proper lengths. The back of the furnace *B* has a step, into which the point of the axis *t* of the drum *K*, in which the beads are placed,

Fig. 606.



Bead-Furnace.

is inserted. This and the hook *l*, suspended from the upper projecting part *N*, serve as supports for the drum in its inclined position. The heat is maintained at a point sufficient to soften, but not to melt, the beads, and the rounded form is imparted to them by rotating the drum by means of the haudle *S*.

Bead-loom. (*Weaving.*) A gauze-loom in which beads are strung upon the threads, the intersections of the threads being occupied by the beads.

Bead-plane. (*Carpentry.*) A molding-plane of a semi-cylindric contour, generally used in sticking a molding of the same name on the edge or on the side close to the arris. A set consists of nine planes, each working a half-round of given radius.

Bead-tool. (*Wood-turning.*) A tool for turning convex moldings. Its end has a semicircular or other curved form, with a sharp edge corresponding to the contour of the bead desired.

Beak. 1. (*Architecture.*) A small pendent fillet forming a channel behind, to prevent water from running down the lower bed of the cornice.

2. (*Shipwrighting.*) The rostrum or prow of a ship. Pisæus is said to have added it to the ancient galleys. It is now revived in the *ram*.

More technically speaking, a part of the ship before the forecastle, fastened to the stem and supported by the main knee.

3. (*Carpentry.*) The crooked end of the holdfast of a carpenter's bench.

4. (*Forging.*) *a*. The point of an anvil. The *horn*. The *beak-iron* or *bick-iron* is all beak.

b. A toe-clip or a horse's shoe turned up against the hoof.

5. (*Nautical.*) *a*. A ram, pike, or *rostrum* on the stem of a vessel to run down an opponent.

b. The part of a ship forward of the stem and supporting the figure-head.

6. (*Chemical.*) The rostrum of an alembic which conducts the vapor to the worm.

7. One of the jaws of a forceps or pliers, named after some real or fancied resemblance to the protruding facial organ; as, —

Hawk's-bill forceps.	*Round-nose* pliers.
Narrow-beak forceps.	*Crane's-bill* forceps.
Long-nose pliers.	*Crow's-bill* forceps.

8. (*Gas-Fitting.*) A gas-burner with one round, smooth hole $\frac{1}{25}$ of an inch in diameter.

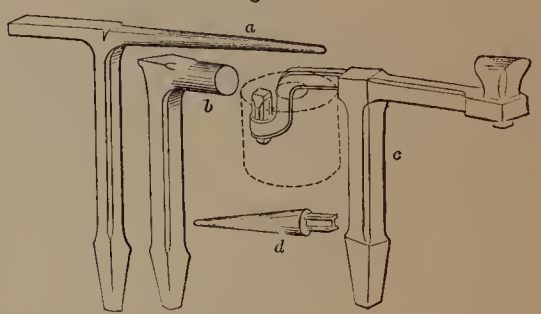
Beak'er. (*Glass.*) An open-mouthed thin glass vessel, having a projecting lip for pouring; used for containing solutions requiring heat, etc. *Beaker-glass*.

Beak'-head Beam. (*Shipbuilding.*) The longest beam in a ship.

Beak'ing-joint. The joint formed by the meeting of several heading-joints in one continued line, which is sometimes the case in floors and doors.

Beak'-i-ron. 1. (*Sheet-iron Working.*) *Beak, Beck, Bick-iron, Bickern*. An anvil with a long

Fig. 607.



Beak-Irons.

beak adapted to reach the interior surfaces of sheet-metal ware.

a. A tool with a long beak, used for rounding sections of stove-pipe, large tin-plate ware, etc. Its tang is set in a square socket in the bench.

b. A tool with a shorter and cylindrical beak.

c. A tool with two beaks, which act *as stakes* or anvils in the interior of ware, differently presented.

d. A conical beak, intended to be grasped in a vise. A stake.

2. The horn of an anvil.

Beale-light. An argand burner, in which the flame is fed with air under pressure, rising through the central aperture. Named after its inventor.

Beam. A straight piece of wood or iron in the frame of a structure, usually occupying a relatively elevated, horizontal, and transverse position: as the *beams* of a ship that support the deck (uniting the sides above the keel, the *spine* of the vessel); the *beams* of a house or barn, stretching across it, and supported by the side walls or posts.

Relative size, character, position, and importance have caused the word to be applied to a long straight piece in a machine or tool, whether poised (*a*), journaled (*b*), or fixed (*c*).

a. The poised *beam* of a balance, to whose respective ends the scales are attached. In the Roman balance or steelyard, the *beam* is not radically equipoised, but one end is longer than the other, so that a smaller weight on one end shall counterbalance a larger on the other in calculated proportions, as in many counter scales and all platform scales. The larger descriptions of the latter have combinations of *beams* or levers.

b. The *working* or *walking beam* of a steam-engine, which is poised at its mid-length, and sustains at its respective ends the connecting-rod to the slide of the piston-rod, and the pitman which drives the crank of the paddle-wheel shaft. In the Cornish pumping-engine, in place of the pitman, is attached the pump-rod. This oscillating piece is usually called a *beam*, and such an engine is sometimes called a *beam-engine*. See also Side-beam Engine.

c. The straight, cylindrical, horizontal bars in a loom, on which the yarn and fabric are wound, called the *yarn-beam* and the *cloth-beam* respectively.

1. (*Building.*) Specific denominations have been conferred upon beams in framed structures of wood.

a. Tie-beam; one uniting the ends of a pair of principal rafters, or a pair of posts, to prevent spreading or divergence.

b. Collar-beam; a horizontal strut connecting and bracing two opposite rafters.

c. Dragon-beam; a piece of timber to receive and support the foot of the hip-rafter.

d. Straining-beam; one used in a truss or frame to confine principal parts in place.

e. Camber-beam; a horizontal beam in a simple span, whose sill has two posts, two struts, and a *camber-beam* uniting the tops of the posts.

A beam bent or built into an arched shape to support a *sill* or *summer*.

f. Hammer-beam; a tie-beam proceeding from the feet of a pair of principal rafters, but having its middle portion removed; the ends at the gap are stayed by ribs springing from corbels below, and support other ribs which spring into an arch.

g. Binding-beam; a tie-beam which binds together portions of a frame.

h. Girder-beam; a tie-beam.

i. Truss-beam; the principal horizontal timbers of a truss, called the *top* and *bottom chord*, and from which proceed the *stays* and *braces* which hold and push respectively, so to speak, and confer rigidity upon the frame.

j. Summer-beam; a central floor or ceiling timber, resting at its ends upon the walls or the girders of the exterior frame, and supporting the ends of the joints which are notched into it.

k. Arched beam; a beam bent, cut, or built into an arched form to support a structure. See Arched Beam.

l. A *built-beam* is one made of several parts scarfed or strapped together.

m. A kerfed beam is one whose under side has a number of transverse kerfs penetrating to a certain depth, so as to enable the beam to be bent. See Arched Beam.

n. Ground-beam; a sill for a frame.

o. The *box-beam* is a form of *girder* having a double *web*, inclosing a *box* or *cell*. (See Girder.) It is usually of iron. See Figs. 216, 218.

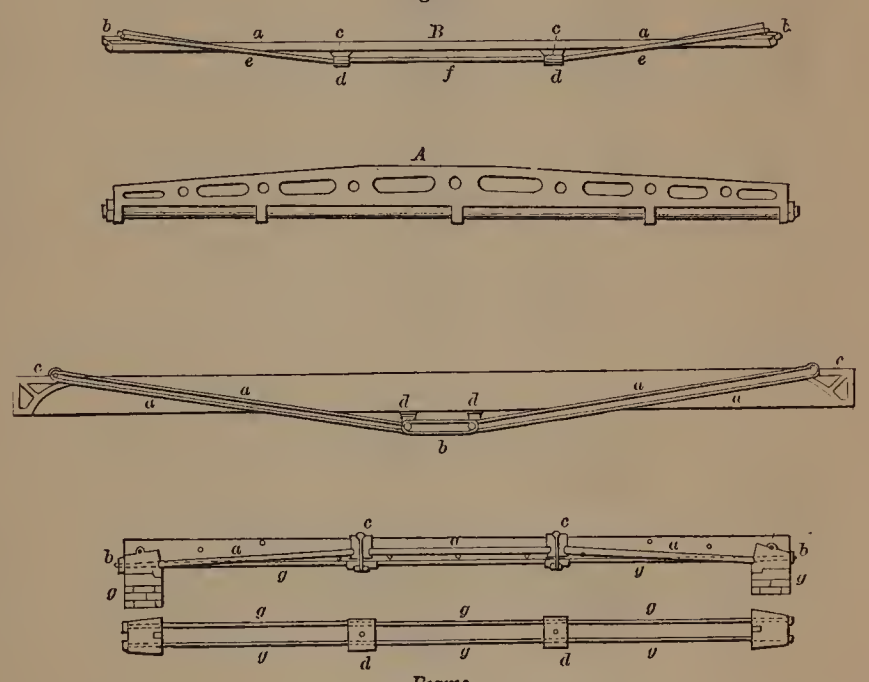
Fig. 608 represents four forms of beams in English use.

B represents a girder on the suspension principle, the wooden girder *a a* being stayed by the tension-rods *e e f*, which are looped over the cast-iron toe-plates *b b*. At points one third of their length from either end the rods are bolted to iron cross-pieces *d d*, which rest against blocks *c c* beneath the beam.

A is a cast-iron girder with a wrought-iron tie-bolt.

The next beam in the figure shows a pair of parallel girders with cast-iron foot-plates *e*, embracing the ends of each, holding them at their distance, and affording points of attachment for the suspension-rods *a a*, which are secured by screw-nuts to the iron saddle-pieces *d d*, the latter being connected by links *b*.

Fig. 608.



Beams.

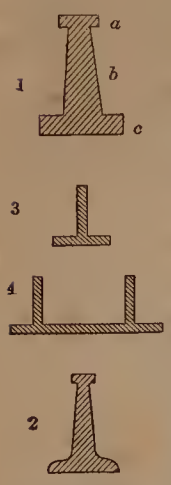
The lower illustration (Fig. 608) is a combined wood and iron girder, used to support a large brewery-vat, weighing, when full, about 100 tons.

The main features of this beam consist of three cast-iron plates *a a a*, whose abutting ends rest against cast-iron blocks *c c*, and which form a kind of arch, supported by a bow and string truss *g g d d*. The ends of the beams rest on shoes *b* and wall-plates *g*.

Mr. Hodgkinson, of England, is said to have determined the true shape of a cast-iron beam, as deduced from his discovery of the fact that the resistance of cast-iron to direct crushing is more than six times its resistance to tearing.

It consists (1, Fig. 609) of an upper flange *a*, web *b*, and lower flange *c*. The sectional area of the lower flange, which is subject to tension, is nearly six times that of the upper flange, which is subject to crushing. In order that the beam, when cast, may not be

Fig. 609.



Cast-Iron Beams. Sections.

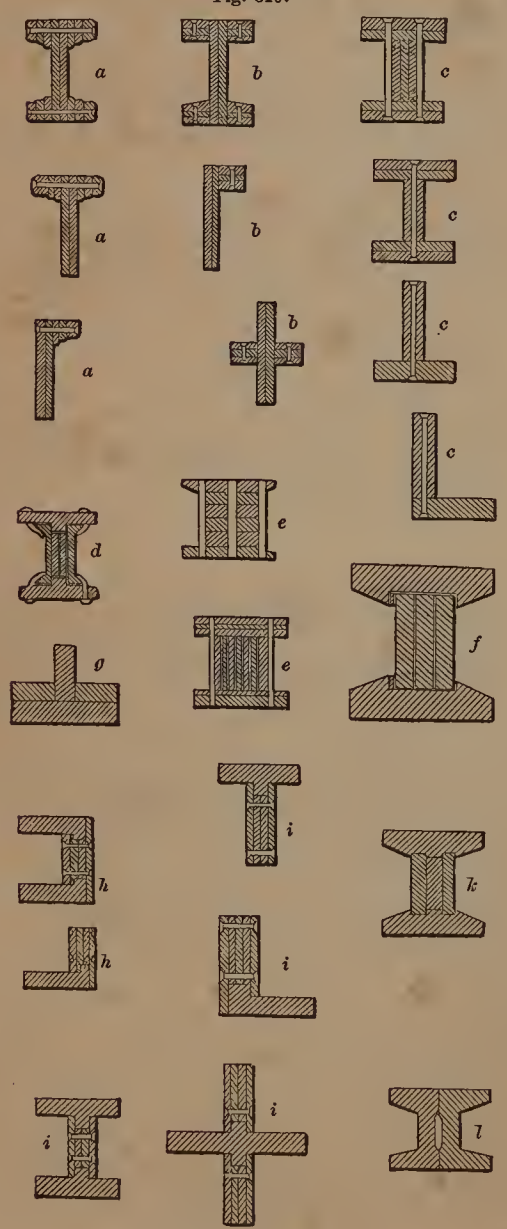
liable to crack from unequal cooling, the thicknesses of the vertical web at its upper and lower edges are nearly equal to those of the flanges at top and bottom respectively.

The most usual shapes of cast-iron beams are shown in the views, which present cross-sections.

1, 2. Double-T beams.
3. Inverted-T beam.
4. Trough-shaped beam.

Fig. 610 shows a number of forms of sections of fagots for wrought-iron beams, the webs and flanges being made up of plates riveted together, and so disposed as to bring the fibrous strength of the iron into the most advantageous positions. The fagots, having been made up, are heated in a furnace, and then rolled by a train whose "passes" have the appropriate size and shape to bring the beam, by successive operations, to the shape and size required in the finished beam.

Fig. 610.

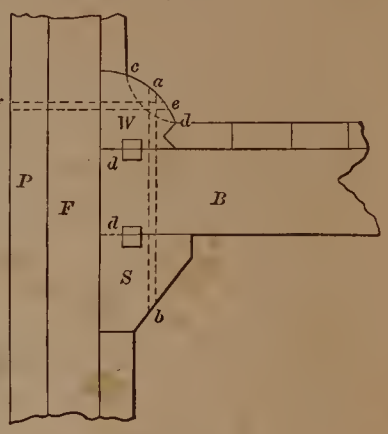


Fagots for Beams.

2. (*Shipbuilding.*) One of the curved transverse timbers of a vessel, supporting a deck.

The end of the beam *B* rests on a shelf *S*, which is bolted through the futtocks *F*, and its upper and lower sides are secured by dowels *d d'* to the water-way *W* and shelf *S*. A vertical bolt *a b* ties the water-way, beam, and shelf together, while another bolt *f e* secures together the water-way *W*, futtock *F*, and planking *P*. *e d* is the convex curve of the water-way, for which may be substituted the concave curve shown in dotted lines. The *water-way* forms a tie above the beam and below the *spirketing*.

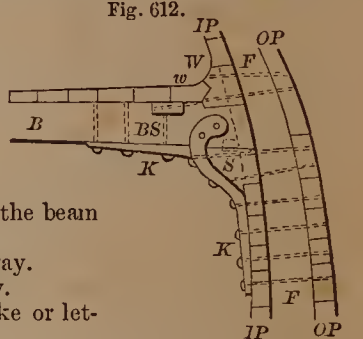
Fig. 611.



Beam.

F, frame.
O P, outside planking.
I P, inside planking.
B, deck beam.
D P, deck planking.
S, shelf to which the beam end is coaked.
W, thick water-way.
w, thin water-way.
B S, binding strake or letting-down strake.
K, forked iron knee.
Dotted lines show the bolts.

Fig. 612.



Ship's Beam and Fastenings.

A *midship-beam* is a ship's deck-beam about the waist.

An *orlop-beam;* a beam of the lower deck, or where one would be were it laid.

3. (*Nautical.*) *a.* A fender-beam is the inclined beam of an ice-breaker, shod with iron. A beam to protect a quay or jetty by receiving the impact of the vessels alongside.

b. The *shank* of an anchor from one of whose ends the *arms* diverge, and whose other end passes through the stock, or conversely.

c. The width of a vessel is called her breadth of beam.

4. (*Weaving.*) *a.* The roller on which the yarn is wound, and from which it is *let off* as the weaving progresses. The *yarn-beam.*

b. The roller on which the goods are wound by a *take-up* motion as the weaving progresses. The *cloth-beam*, or breast-beam.

5. (*Railroad Engineering.*) The *swing-beam* is a cross-piece supported by the frame of the truck, and sustaining the car-body in such manner that a certain lateral motion and play is allowed.

6. (*Currying, etc.*) The board over which a hide is placed to be *unhaired*, *struck*, or *shaved* by the knives adapted to those processes.

The *unhairing-beam* is a cylindrical table on which the hides from the lime-pit are placed while the hair is scraped off.

The *striking-beam* is a cylindrical horse on which the hides are occasionally scraped by a triangular steel knife, during the time they are drying after removal from the tanning-liquor.

The *currier's beam* is an inclined post over which the hide is stretched to be shaved by the currier's knife.

The currier's beam in a slanting position is shown in the ancient paintings of Kourna, Thebes.

7. *Swipe-beam;* the counterpoise lever of a draw-bridge.

8. The oscillating lever of a steam-engine. A working-beam or side-lever.

9. The main piece in the frame of a plow to which the handles, clevis, and standard are attached.

10. The straight working-edge of the stock of a square or bevel.

11. The bar on which slide the sockets carrying the points, pencil, or pen, of a *beam-compass.*

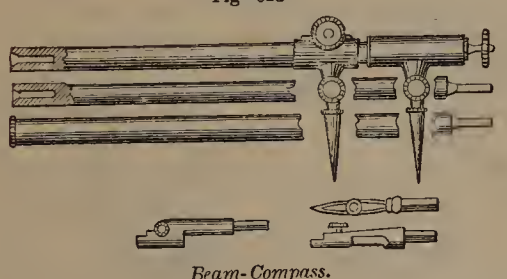
12. The *pole* or *tongue* of a carriage (*not much used*).

Beam-board. The platform of a steel-yard or balance.

Beam-cen'ter. (*Steam-Engine.*) The pin on which the working-beam vibrates.

Beam-com'pass. Sometimes called a *trammel.* An instrument for describing

Fig 613.



Beam-Compass.

large circles. It has a *beam* or rod, and two sliding sockets which carry the steel point and the pencil or pen points. Set-screws on the sockets hold them to their places on the beam.

Beam-en'gine. (*Steam-Engine.*) An engine with an oscillating beam, to whose respective ends the connecting-rod from the piston and the pitman from the crank are attached.

In the Cornish engine the connecting-rod is at one end and the pump-rod at the other end.

To avoid the elevation of the working-beam, so common in our Atlantic and Eastern river steamers, the side-lever engine has been invented. This brings the engine into more compact form, throws the weight nearer to the keel, and places the engine below the water-line in some cases, — an especial advantage in war-vessels. See SIDE-BEAM ENGINE; MARINE STEAM-ENGINE; LEVER-ENGINE.

The old atmospheric engine of Newcomen was a beam-engine, and he is justly regarded as the inventor of the *working* or *walking beam.* (See STEAM-ENGINE; ATMOSPHERIC-ENGINE.) The pump-rod and the piston were suspended by flexible connections from arcs on the ends of the working-beam. When Watt came to the work, he devised the parallel motion as a means of communicating a vertical motion to a rod from a point on a beam which oscillated in an arc.

Beam-fill'ing. (*Masonry.*) Filling-in courses of brick or stone between the ends of beams or joists where they rest upon a wall.

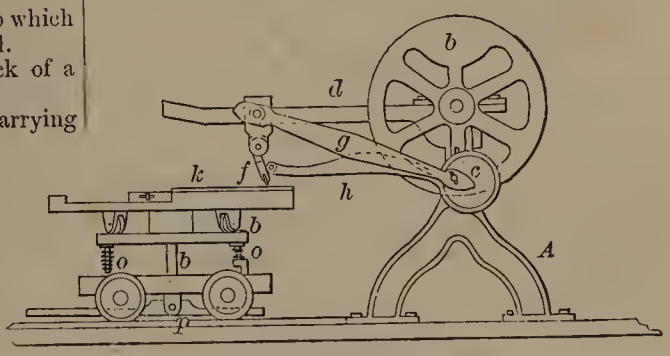
Beam'ing. 1. (*Weaving.*) The operation of winding the yarn upon the beam of a loom.

The yarn-threads are laid uniformly in the order in which they were placed in the *warping-mill* by means of a *separator* or *ravel,* which consists of a number of pieces of cane fixed to a rail of wood, so as to resemble a rake. The threads pass between the teeth, and the yarn is spread on the beam to the required width.

2. (*Leather.*) The operation of working hides with a slicker over a beam.

Beam'ing-ma-chine'. (*Leather.*) One in which hides supported on a sliding or rolling carriage are

Fig. 614.



Beaming-Machine.

operated upon by a pendulous slicking-tool which has a vibratory motion. The motion of the carriage brings different parts of the leather under the influence of the tool.

In the illustration, the leather is supported on a rotatable tablet *k* resting on a carriage *o o,* which runs back and forth on rails. The tablet *k* is vertically adjustable by means of the treadle *p b.* The beaming-tool *f* is brought in contact with the leather or raised therefrom by means of the eccentric-rods *g* and rod *h,* which are moved as required by means of the wheels *b c.*

Beam-knife. The two-handled knife used by curriers to shave hides when they are stretched over the beam. See CURRIER'S KNIFE.

Beam-line. (*Shipwrighting.*) The line indicating the intersection of the top of the beams with the frames.

Bean-har'vest-er. (*Agriculture.*) A machine for cutting bean-haulm and placing the vines in windrow, cocks, or in a receptacle of the traveling machine.

There are several forms: —

A hand-puller, having a long row of teeth to catch, and a movable clamp which comes down upon the teeth to grip, the vines.

A machine with a broad, flat oblique share which cuts the roots beneath the surface, followed by lifting-bars which raise, and a rake which collects, the vines in a bunch. By oscillating the rake, the bunch is dumped upon the ground.

A plow which cuts the vines below the surface, and lifting and directing rods which conduct them to a box on the machine.

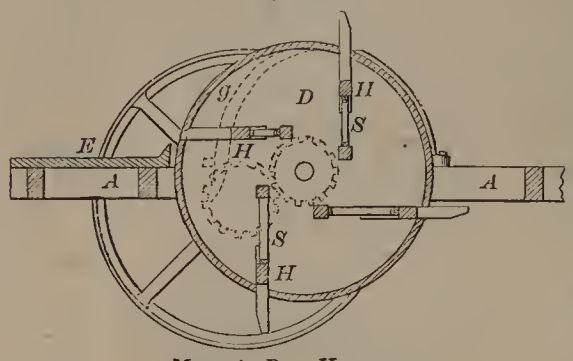
A two-wheeled machine, having a rotating wheel with claws which catch, lift, and then deposit the vines in a box on the machine, whence they are dumped in cocks.

A machine with a pair of nearly horizontal toothed wheels rotating in apposition, so as to grasp the vines at the ground surface and lift them so that they may be grasped by a traveling elevator-belt, which deposits them in the box of the machine.

A wheeled machine in which the pullers *H* are guided in and out of a hollow cylinder by a cam-

guide *g*, so as to catch the haulm, lift it, and carry it upward and over, and then, by retraction of the

Fig. 615.



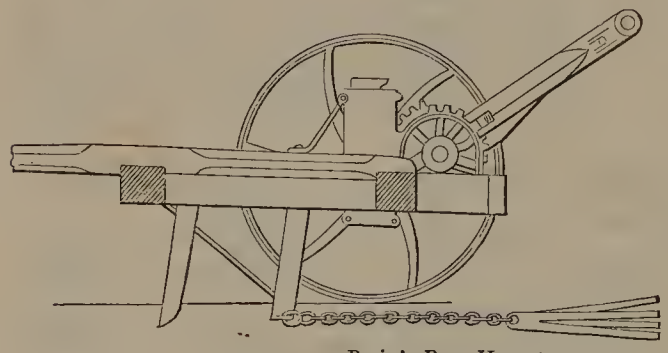
Munger's Bean-Harvester.

puller-arms, leave the vines upon the platform *E* on the rear of the frame *A*. The pullers rest upon springs *S* inside the cylinder, and are projected by the same in the intervals of their retraction by the cam-guide.

A form of machine which follows the row of plants, and in which the rotating puller-wheel has a continuous series of pairs of clamps, which close as they come over the row, grasp and lift the vines, and then open to deposit them in a chute which carries them to a transversely moving apron which deposits them.

A machine (Fig. 616) having L-shaped cutters, which sever the vines below the surface of the

Fig. 616.

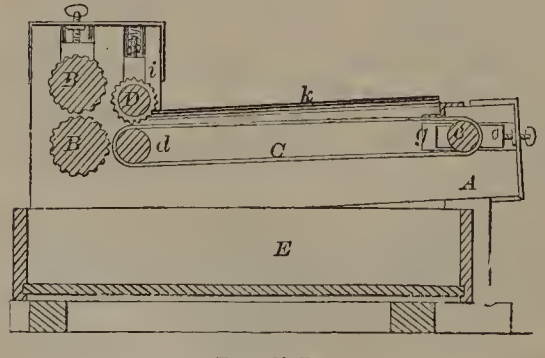


Rosier's Bean-Harvester.

ground, from which they are raised by a trailing device, consisting of diverging prongs, and left upon the surface of the ground.

Bean-mill. (*Husbandry.*) A mill for splitting beans. Used in England in preparing them for horse-feed.

Fig. 617.



Bean-Sheller.

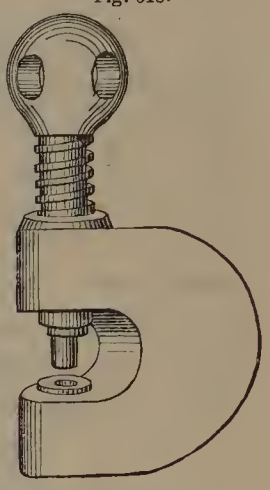
A mill for grinding beans to meal.

Bean-shel'ler. A machine for removing the hulls from beans. In the example, the pods are fed by an endless apron *c* longitudinally, and cut by the serrated wheels *i*; the toothed rollers *B B* then carry off the hulls, allowing the seed to drop into the receptacle.

Bean-shot. (*Metallurgy.*) Copper in grains. Produced by pouring the melted copper into water.

Bear. (*Metal-working.*) 1. A portable punching-machine for iron plates. A *punching-bear*.

Fig. 618.



Bear.

2. (*Nautical.*) A heavy block shod with matting, and used to scrub the decks.

Beard. 1. (*Carpentry.*) The sharp edge of a board.

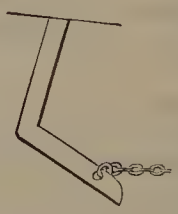
2. (*Knitting.*) The hook at the extremity of a needle in a knitting-machine, which retains the yarn.

3. The barb of an arrow or fish-hook.

4. (*Agriculture.*) The awn of grain, as of barley, which is removed by *hummeling*.

5. (*Printing.*) The part of the type between the shoulder of the shank and the face.

6. (*Locks.*) A spring-piece on the back of a lock-bolt of a common kind, to hold with a moderate pressure in either of its positions, and prevent its rattling in its guides.



Beard'ing. (*Shipwrighting.*) *a.* A beveling or rounding; as of the adjacent parts of the rudder and stern-post, to give the former a greater range of motion without jamming against the latter.

b. The curving of the dead-wood to suit the shape of the ship's body.

Beard'ing-line. (*Shipbuilding.*) The trace of the inner surface of the ship's skin upon the keel, stem, and stern-post.

Bear'er. Anything used by way of support to another weight.

1. (*Carpentry.*) *a.* A member employed to carry other portions, as joists used in supporting lead flats or short pieces to support gutters.

b. A *bearing-partition* is one that supports a structure above.

2. (*Engineering.*) *Bearing-piers* and *bearing-walls* are supporting structures.

3. (*Lathe.*) That part of the lathe which supports the puppets.

4. (*Furnace.*) A supporting bar beneath the fire-bars of a furnace.

5. (*Mill.*) The *housings* or *standards* of a rolling-mill, in which the gudgeons of the rollers revolve.

6. (*Printing.*) *a.* Type or furniture letter-high, to protect the face of the type in printing or stereotyping.

b. The overlay or frisket sheet.

7. (*Music.*) In an organ, one of the thin pieces of hard wood fastened to the upper side of a *sound-board*, to form guides for the register-slides which command the openings in the top of a wind-chest leading to the pipes of the separate systems of pipes which form *stops*. See STOP; ORGAN.

Bear'ing. 1. (*Architecture.*) *a.* The span of a beam between its points of support.

b. The *bearing at the ends* or *wall-support* is the length of the rest on the wall or pier.

2. (*Machinery.*) *a.* The portion of an axle or shaft in contact with its collar or boxing.

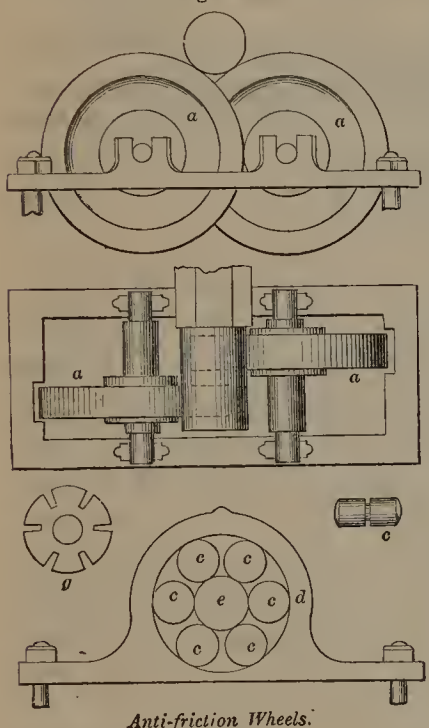
b. The portion of the support on which the gudgeon rests and rotates.

3. (*Vehicle.*) One of the pieces supporting the framework of a carriage and resting on the axle.

4. (*Railroad Engineering.*) One of the chairs supporting the framework of a railroad car or truck, and resting on the journal of the axle, outside of the wheel.

One mode of lessening the friction of journal-bearing consists of a rolling support by means of wheels *a a*. This is familiar in the mode of hanging grindstones.

Fig. 619.



Anti-friction Wheels.

The same idea amplified has been adopted for the axles of cars and carriages, consisting of an annular system of rollers *c c* in the box or hub *d*, which forms a rolling bearing for the axle, the individual rollers of the system rotating on their axes, and in some cases revolving, also revolve around the common axis, namely, the axle of the carriage. *g* is a plate having radial slots in which the rollers *c* are journaled.

In this case the bearings *c c* are rollers, not wheels, as the weight is not imposed upon the axles of the wheels, but on their surfaces. See also STEP.

Bear'ing Bin'na-cle. (*Nautical.*) A small binnacle on the fife-rail, in the center and forward part of the poop.

Bear'ing-neck. The part which revolves within the pedestal brasses, and supports the weight or strain. The journal of a shaft.

Bear'ing-pile. (*Hydraulic Engineering.*) A pile driven as a pillar to bear a superstructure.

When driven till they reach a firm substratum, they may bear a load of 1,000 pounds for each square inch of head.

When standing in relatively soft ground, not over one fifth of the above.

The diameter should not be less than one twentieth of the length. If rocks are expected to be met with, the point should be shod with iron; such shoe may be one hundredth the weight of the pile. An iron hoop binds the head, to prevent spreading. It is driven by a PILE-DRIVER (which see). See also RINGING-ENGINE; MONKEY-ENGINE; PILE-SAW, etc.

Bear'ing-rein. (*Saddlery.*) The rein which belongs to the bridle, and which is attached to the bit and looped over the check-hook in carriage-harness, and over the hames in wagon-harness.

Bear'ings. (*Shipwrighting.*) The widest part of a vessel below the plank-shear. The line of flotation of the loaded vessel when trimmed.

Beat'er. 1. (*Agriculture.*) The striking portion of a thrashing-machine or other mill which acts by percussion.

2. (*Cotton, etc.*) *a.* A scutcher.

b. A blade used in breaking flax or hemp.

3. (*Weaving.*) The *lathe* or *batten* of a loom for driving the *weft* into the *shed*, compacting the fabric.

4. A hatter's mallet.

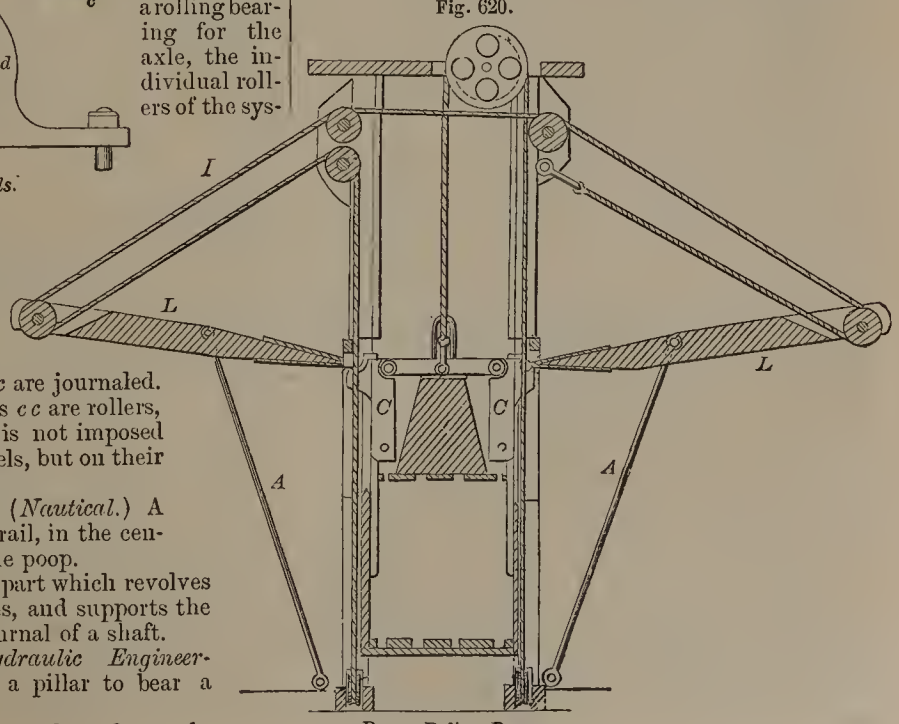
5. (*Knitting-machine.*) Another name for the JACK (which see).

Beat'er-press. For baling. One in which the bale is made by beating it into smaller bulk; or, which is more usual, in which the bale is packed by beating, and finally solidified by direct and maintained pressure.

In the example (Fig. 620), the beater is lifted by means of its toggle-links and pressure-arms *C C*, the latter drawing inward to avoid contact in raising, and the arms become sockets for the ends of the toggles *L L*, when the beater becomes the follower of the press.

The fulcrums of the toggles are formed by the ends of the pivoted rods *A A*, which gradually assume verticality as the outer ends of the toggle-

Fig. 620.



Beater Baling-Press.

levers *L* ascend, when the rope *I* is tightened. This is first a *beater* and then a *toggle* press.

In other cases the motive-power is placed a story below the floor of the barn, from whence the hay is charged into the press-box. The draft animal attached to the sweep rotates the capstan, which is made effective either to raise the beater or to move the toggles which raise the lower follower.

Beat'ing. The process of hammering gold or silver into leaf. See GOLD-BEATING.

Beat'ing-brack'et. (*Weaving.*) The *batten* or *lathe* of a loom. The movable bar which closes up the *woof*-threads.

Beat'ing-en'gine. 1. (*Paper-making.*) A machine having a revolving cylinder, with cutters operating against a concave similarly armed, to cut rags into stuff for paper-pulp.

Two or more of such engines are employed: a *washer* operates coarsely upon the stuff; a *finisher* completes the work. The first brings the material to half-stuff, in which condition it is bleached; hence arise the terms STUFF-ENGINE, HALF-STUFF ENGINE (which see).

2. (*Cotton Manufacture.*) The machine in which cotton or other fiber is beaten to rid it of dust, and to loosen it so that it may make a *bat* suitable for farther operations in course. See Fig. 601.

Beat'ing-machine'. (*Cotton, etc.*) A machine in which the bale-cotton is opened and loosened out so as to rid it of the dirt and trash, and deliver it in a comparatively loose *bat*. The machine has many modifications and names: *wolf*, *devil*, *opener*, *willower*, *scutcher*, etc. See COTTON-CLEANING MACHINE.

Bea'ver. (*Fabric.*) A heavy, milled woolen cloth for overcoats.

Bea'ver-teen. (*Fabric.*) *a.* A cotton twilled goods in which the warp is drawn up into loops, forming a pile. This is left uncut, which distinguishes the fabric from velvet, in which the pile is cut.

b. A strong cotton twilled goods for men's wear. It is a kind of smooth fustian shorn after being dyed. If shorn before dyeing, it is called moleskin.

Be-casse'. (*Nautical.*) A large Spanish boat.

Beche. (*Well-boring.*) A tool for grabbing a rod when it has broken in the bore.

Beck. A vat or vessel used in a dye-house. A *dye-beck* contains a dyeing solution; a *soap-beck* contains soap-suds. See BACK.

Beck'et. (*Nautical.*) A bracket, pocket, loop, or rope to hold spars, ropes, etc., in position, to prevent their swaying about or lying around loose.

Bed. 1. (*Masonry.*) *a.* The line of the direction of the natural strata of stones in the quarry.

b. The horizontal surface of an ashlar or building-stone worked for building or in position; the respective surfaces are the *upper* and *lower* beds. The stone should lie horizontally, as it laid in the quarry.

c. The surface of a voussoir, represented by the abreuvoir. That surface of a quoin in an arch which abuts upon another quoin or a skew-back.

d. A course of stones or bricks in a wall.

e. The lower surface of a brick, shingle, slate, or tile in position.

f. The place prepared for the erection of a wall; the place in which a block or brick is laid.

g. A layer of hydraulic mortar on the extrados of an arch.

2. (*Railway Engineering.*) The foundation of a roadway; in a railway, that part on which the ties immediately rest, including the ballasting.

3. (*Machinery.*) *a.* The foundation-piece of a machine or engine, as the *bed-plate* of a steam-engine, and the same of smaller structures, lathes, drills, etc.

b. The shears of a turning-lathe to which the puppets are attached.

c. The lower die of a punching-machine.

d. The lower stone of a grinding-mill.

e. The table of a planing-machine on which the work is dogged.

4. The wooden block out of which are hollowed the mortars in which the materials for gunpowder are compounded.

5. (*Shipwrightin .*) *a.* The cradle of a ship on the stocks.

b. The part of a bowsprit having the greatest diameter.

6. (*Carpentry.*) The surface in a plane-stock on which the plane-iron is supported.

7. (*Printing.*) The platform of a printing-press on which a form is laid.

8. (*Weapons.*) *a.* A frame for supporting a piece of ordnance, more especially a mortar; as, a *mortar-bed.*

b. The hollowed place in a gun-stock which receives the barrel.

9. (*Vehicles.*) The box, body, or containing receptacle of a vehicle.

10. (*Mining.*) A seam or horizontal vein of ore.

11. (*Domestic.*) An article of furniture to sleep or rest on.

Goose-feather beds and pillows were introduced by the Romans during the government of the Cæsars. They were imported from Egypt. Introduced into England by the returning Crusaders.

Besides feathers, many other substances have been and are still used for beds; as, straw, heather, rushes, hair, corn-shucks, moss, sponge, excelsior (wooden shreds, curled).

Among primitive nations the skins of wild beasts have been much employed, and of these were the beds of the ancient Britons at the time of Cæsar's invasion. Their Roman conquerors are said to have taught them the use of straw; to some extent of grain also, it would seem. The down of the eider-duck of the Scotch cliffs is the softest and most luxurious material.

The beds of the Greeks were according to taste and ability. The poor wrapped himself in a rug, and laid on straw or weeds, with a billet of wood under his head. In cold weather sheep-skins were added. The richer had blankets and fine rugs. When he undressed, he added a linen sheet. He rolled himself up in his bed-clothes.

Bedsteads were an afterthought, and even then we find that the occupants swaddled themselves in the blankets. They did not understand, it appears, how to make a partnership matter of it, — bed-clothes of generous area covering a pair. See BEDSTEAD.

Air-beds were known several centuries ago, being made of fabric rendered air-proof by paint or varnish. The annexed cut is from the first German edition of Vegetius, A. D. 1511, and represents some soldiers reposing on one in time of war. The mode of inflation by bellows is also indicated.

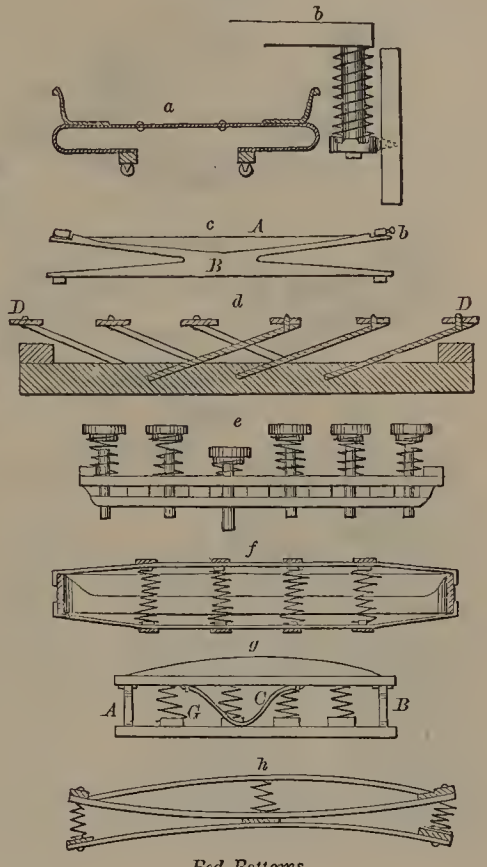
We see indications of the same idea in the account given of the sports of Heliogabalus, who had collapsing cushions wherewith he tricked his guests. See AIR-BED. See also HYDROSTATIC BED.

We are indebted to Dr. Arnott for the invention of the water-bed, which was contrived by him for the purpose of supporting the body without sensible inequality of pressure, thus preventing bed-sores. Clark, in 1813, and MacIntosh, in 1823, improved the matter by contributing a better material. The

Fig. 621.

Air-Bed

Fig. 623.



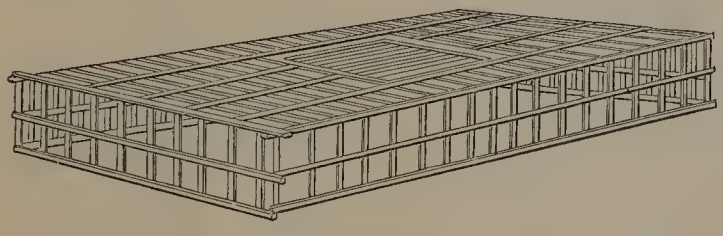
Bed-Bottoms.

india-rubber cloth was long known simply as "Macintosh."

Bed-bot'tom. A device attached to a bedstead on which the bed immediately rests. The object to be attained is to secure sufficient strength with a certain degree of elasticity, and for this purpose many contrivances have been devised, among the best known of which is probably the old-fashioned "sacking" bottom, having eyelet-holes around its margin, through which a rope was passed for securing it to pegs on the bedstead. Another common arrangement is merely a series of slats passing from side to side and resting in notches on the rails.

The framework in the accompanying cut is made from the sticks of the palm-branch; so says Wilkinson. It, and other structures similarly made, are known by the general name of *kaffass*. The bedstead of palm-branches, called a *baïs*, and mentioned by Porphyry, was probably of this kind. It probably formed the body of some of the couches and ottomans represented in the ancient paintings on the Egyptian tombs. The bed-bottoms made in this way are usually 7 by 3½ feet, and from 1 to 2 feet in hight.

Fig. 622.



Egyptian Mattress.

In Fig. 623 are shown several varieties, some in section and others in elevation.

a, the longitudinal spring-slats are curved over at the ends and attached to the cross-bars.

b, the slat-ends rest on springs whose lower coils rest on lugs with shanks which screw into the rail.

c has spring-bars *B* and a tension-wire *A*.

d has spring-pieces inserted obliquely into the slat.

e has disks and spindles, spring supported.

f has spiral springs between upper and lower webs.

g has springs supporting an upper padded frame.

h has a system of curved springs, slats, and spiral springs.

The above is a mere sample of hundreds of varieties. Woven wire fabric or rattan is the best in warm weather.

Bed-clothes Clasp. A device for preventing the accidental displacement of bed-clothes; as, for instance, a pair of pivoted jaws kept closed by a spiral spring and fastened to the bedstead.

Bed'ding. The seat on which a boiler or other structure rests. See BED.

Bed'ding-stone. (*Bricklaying.*) A marble slab, accurately level, on which the rubbed side of a brick is tested to prove the truth of its face.

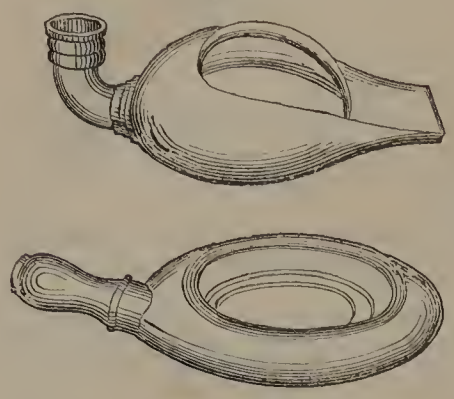
Bede. A miner's pickaxe.

Bed-lathe. The usual form of lathe, in which the puppets and rest are supported upon two parallel and horizontal beams or shears.

Bed-mold'ing. A collective term for all the moldings beneath the corona or principal projecting member of a cornice, which, without bed-moldings, would appear too much like a mere shelf.

Bed-pan. (*Domestic.*) A convenience for the sick-room, for the use of invalids or the bedridden.

Fig. 624.



Bed-Pan.

Bed-plate. (*Machinery.*) The foundation-plate to which the frame of a machine is bolted, as of a steam-engine.

In BLANDY'S portable engine, the engine and working machinery are all attached to a continuous hollow iron bed-plate in the form of a cylinder. The feet for this bed-plate fit into seats on the boiler, so as to be removable therefrom when required. The principal object is to prevent the unequal expansion of the boiler and engine from throwing the latter *out of true*, or from straining the joints of the former.

Bed'stead. A piece of furniture supporting a mattress or bed.

Bedsteads were common in Egypt and among the later Greeks. They were only used, however, by the wealthier classes. Many ornate bedsteads are represented in the tombs at various parts along the river Nile.

Among the earlier notices is the iron bedstead of Og, king of Bashan; it was nine cubits long and four broad (Deut. iii. 11). This was adapted for a man twelve feet high. The Rabbinical writers have exercised their ingenuity upon Og, and their highest flight concerns a bedstead, the first mention of the article in their chronicles. Rabbi Ben-Somebody — we merely condense — says that Og lived before the flood, and was so tall that the water did not reach his knees, and so he waded through. Escaping this destruction, he afterwards turned up as Eliezer of Damascus, Abraham's servant. Abraham was of a size equal to 74 ordinary men, but was no match for Eliezer, except in scolding, which he could do most profoundly. As he was blowing up Og one day, the latter trembled so violently as to jerk out a double tooth, which the patriarch converted into an ivory bedstead. It was probably carious, and so Abraham sawed off the fangs to bring them to a length for legs, and shoveled out the hole so as to hold a few camel-loads of straw. Abraham appears to have discharged him, or Og ran away, and again appears in opposition to Moses, who killed him.

Rabbi Jochanan admits that the above is only tradition, but says that he himself chased a roe into the hollow shin-bone of the defunct, and followed it three miles without finding his roe or the end of the hole. He became tired and returned disgusted. A huge — bone.

The bedsteads of the luxurious Greeks had four rails, legs, straps to support the mattress, a head-board, and sometimes a foot-board. They were made of solid maple or boxwood; sometimes veneered with costlier wood, tortoise-shell, or ivory. They had ornamental feet, sometimes of silver.

The mattress was of linen, woolen cloth, or leather, and stuffed with straw or wool. Round and square pillows were used. They were provided with soft and thick woolen blankets and sheets. The Greeks wore nightgowns. The sleeping arrangements of the wealthy Greeks seem to have been good, but the Asiatics said "the Greeks do not know how to make a comfortable bed."

> "But no town with Miletus vies
> In the bridal-bed's rich canopies."
> CRITIAS; quoted by Athenæus, A. D. 220.

The Roman bedsteads were magnificent, and the weary climbed on to them by step-ladders on the open side; the other was closed by a side-board. The open side was *sponda*, the closed *pluteus*; the latter for the weaker vessel.

The mattresses or beds were stuffed with wool or feathers.

We cannot spare room to describe the gorgeous counterpanes.

The bedsteads had canopies, but we do not read of curtains or testers.

The bed, or rather bedstead, of Ware, mentioned by Shakespeare, is still in existence, and is to be seen at one of the inns in that village. It is twelve feet square. Many innovations have been made on the old-fashioned four-post bedstead. That known as the four-poster was, however, provided with four high posts and a tester, forming, with the curtains, a complete canopy by which the sleeper, if so disposed, could be fully protected against fresh air, and enjoy the pleasure of breathing as vitiated an atmosphere as he pleased.

It was formerly the general practice to make the bed-bottom of coarse canvas, having eyelet-holes along its edges, through which a cord was passed, and thence over pins in the side, top, and bottom rails, which supported the bed-bottom, the arrangement admitting of being laced up as tight as desired. Of late, various arrangements of slats have prevailed. See BED-BOTTOM.

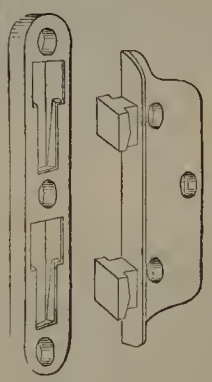
Many improvements have also been made in the manner of putting the parts together, so that the bedstead can be set up and taken down with greater facility.

Invalid-bedsteads are made with rising sections, so as to bring the body to a reclining or sitting posture for relief by change of position.

Wardrobe-bedsteads are modes of concealing beds in chambers to be occupied during the day, where the accommodations of the domicile are limited.

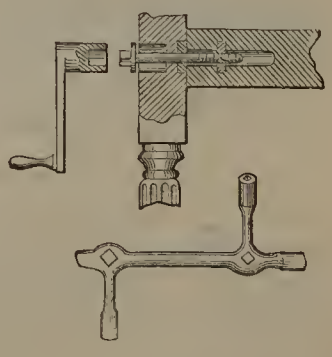
Bed'stead-fast'en-er. A device consisting of two parts, one attached to the end of the rail, and

Fig. 625.



Bedstead-Fastener.

Fig. 626



Bedstead-Wrench.

the other to the side of the bed-post, by which the parts are locked together or readily detached.

There are many varieties: some of metal; others

screws on the rails and screw-sockets in the posts, dovetail tenons on the ends of the rails and slots or sockets in the posts, etc.

Bed'stead-key. See BEDSTEAD-WRENCH.

Bed'stead-wrench. A crank-wrench employed in turning the bolts which secure the rails to the posts of bedsteads. A nut is inserted at a lateral mortise in the rail, so as to present its aperture in the path of the screw-bolt, which is rotated by the wrench. A tenon on the end of the rail fits into a mortise in the face of the post.

Another form combines sockets of various sizes and a screw-driver.

Bed-stone. (*Milling.*) The term applied to the lower or stationary mill-stone. The lower stone, however, in some mills, is the runner. In some mills, again, the stones are driven in contrary directions. The term *bed-stone*, in such cases, loses its significance, and it becomes the *runner* or the *lower runner* respectively.

Bed'way. (*Mining.*) An appearance of stratification, or nearly horizontal line of marking in granite.

Bee. (*Nautical.*) One of the pieces of plank bolted to the outer end of the jib-boom to reeve the foretop-mast stays through.

Bee-block. (*Nautical.*) One of the blocks of hard wood bolted to the sides of the bowsprit-head, for reeving the foretop-mast stays through.

Bee-feeder. (*Husbandry.*) A device for feeding bees in bad weather or protracted winters. For the materials of the food, see Langstroth or other apiarists. The mode is usually a small perforated piece of board which floats on the liquid food.

Bee-fu'mi-ga-tor. (*Husbandry.*) A blower for driving a smudge into a hive to expel the bees, or compel them to retire to a certain part of the hive, while honey is removed, or the hive examined and cleaned. Fumigation is also used to partially paralyze the bees while the swarm is being parted.

Bee'hive. (*Husbandry.*) A box, crate, basket, or hollow log in which bees are kept for the sake of their honey. In the old scripture and classic lands they lived, and yet live, in the clefts of the rocks. They are new-comers to this hemisphere, and with us live in a wild state in hollow trees. In California, it is said, they have taken to the cliffs. A sawed-off section of a hollow log is known in the West and South as a *gum*, possibly from the use of a log of the *gum-tree* for that purpose. Whether for a beehive or a curb for a spring it bears that name; and the gum-wood is only common in some localities, whereas the name is universal.

Hybla and Hymettus are classic bee-ground. Eumelus of Corinth wrote a poem on bees 741 B. C. There are enumerated 292 species of the apis genus. The honey-bee was introduced by the English into Boston, 1670, and is spreading over the continent. The men were lately alive who professed to recollect the time when the swarms first made their appearance on the west side of the Mississippi. They are said to keep a little in advance of civilization. Huber wrote on bees in 1796, and the bee-anatomists and physiologists are but his followers.

Samson found a swarm of bees in the land that flowed with milk and honey. Honey was prohibited as an offering on the altar under the Levitical law, but its first-fruits were presented for the use of the priests. (Lev. ii. 11, 12.)

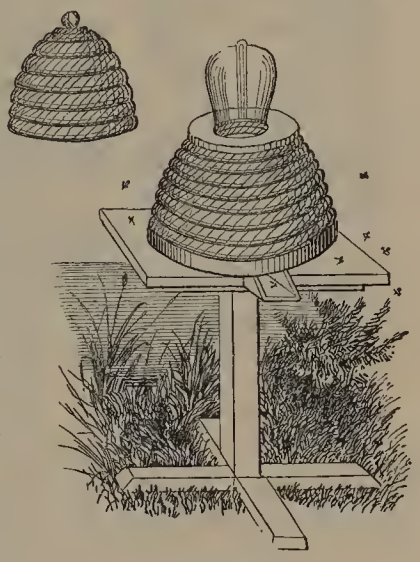
Honey was a favorite article of food in ancient Egypt, but the tombs are silent as to the treatment of the bees.

Varro (50 B. C.) recommends that hives be made of basket-work, wood, bark, hollow trees, pottery, or reeds, and be contractible according to the size of the swarm. He recommends a pane of transparent stone (*lapis specularis*), so as to enable the apiarian to see the bees at work.

Sallust recommends cork; a very good suggestion. They are yet made of cork in some parts of Southern Europe; the wood being removed, leaves the cork-bark as a cylinder. In Greece and Turkey earthenware hives are in common use. The ancient English hives were baskets of unpeeled willows.

Beehives made of helical coils of twisted straw are in common use in England, as well as those of wood. A representation of one of the former kind is shown in the illustration, the cover being removed to show the interior glass cap. The materials of which hives are made differ in various countries, and the variations in construction are almost infinite.

Fig. 627.



Straw Beehive.

Pepys thus refers to glass beehives: —

"After dinner to Mr. Evelyn's; he being abroad, we walked in his garden; and a lovely, noble ground he hath indeed [Sayes Court]. And, among other rarities, a hive of bees; so as, being hived in glass, you may see the bees making their honey and combs mighty pleasantly." — *Pepys's Diary*, April, 1665.

Movable comb-hives were invented in 1792. In their present form and adaptation they are considered the invention of Langstroth.

In some countries it is usual to carry bees from place to place in their hives for change of pasture. This practice is extensively carried on in Egypt, where great numbers of hives are often transported on boats from place to place along the Nile, according to the succession of flowers in different districts. An analogous custom of transporting bees from one locality to another, for similar reasons, has long been prevalent in Persia, Asia Minor, and Greece; and in Scotland, during the season when the heather is in bloom, many hives are annually carried to the heaths from districts not in their immediate vicinity.

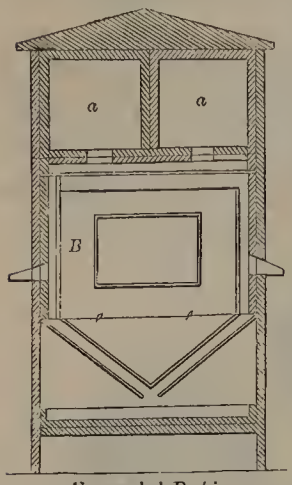
In Poland, the bees are transported in large colonies from their winter-quarters to their summer pasture, and back again when the weather becomes inclement.

The objects principally held in view in the manifold attempted improvements in beehives are the prevention of the access of moths to the hive, and the separation of the portion containing the spare honey from the breeding portion. It is also desirable that perfect ventilation and ready access to any part of the hive should be attained, and that there should be no difficulty in removing the surplus honey.

These, and other considerations involving cheapness, have been the subjects of improvements almost innumerable.

Fig. 628 is a fair illustration of one favorite form of hive. It is suspended by cleats on the sides. It has a large breeding-chamber *B*, a glass door, and a sloping floor to carry off dirt. Above are two sliding, removable boxes *a a* for the abstraction of honey without disturbing the contents of the main chamber.

Fig. 628.

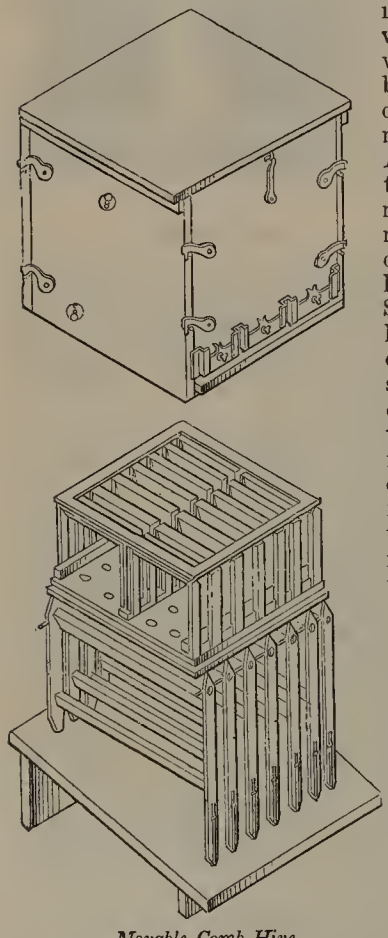


Suspended Beehive.

Fig. 629 shows the arrangement of movable combs in a box whose sides are removable from the interior works. The upper series of combs are for removal of honey.

In Fig. 630, the hinged top and spare honey-box compartments admit of being lifted from the lower breeding-hive; the entrance to the lower hive is regulated by an invertible bee-trap with swing-bars, by which the size of the apertures may be changed. A groove is cut in the bottom for a moth-trap, which may be opened by dropping a hinged lighting-board. Sectional frames have varying gains on their different sides, which, by connection with the entrance-slot, may prevent the queen or drones from passing through or impeding the passage of the workers.

Fig. 629.

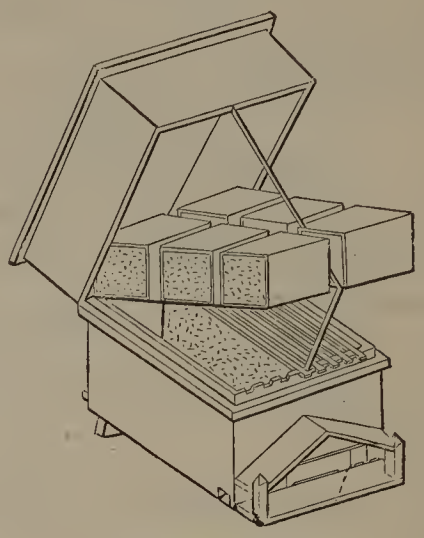


Movable Comb-Hive.

Bee'hives, Swarm-in'di-ca-tor for. (*Husbandry.*) An arrangement for detecting the gathering of a swarm previous to their departure in quest of other homes and pastures new. It is usually an alighting-board, so arranged as to cause an alarm when a certain weight of outlying bees has accumulated upon it, — this being their habit previous to flight.

Many of the improvements in hives have special reference to preventing swarming, by division of the inmates into two bodies with room for expansion of each party. These attempts to anticipate or defeat the natural inclinations of these little *Hymenopteras* are only partially successful.

Fig. 630.



Kretchmer's Beehive.

Beer. A fermented infusion of malted grain, to which hops is usually added.

The term is also applied to beverages made of infusions of roots and herbs.

"When the vine would not grow and be fruitful, Osiris taught the inhabitants to make drink of barley, little inferior in strength and pleasant flavor to wine itself." — DIODORUS SICULUS (60 B. C.).

Hecatæus, in his "Description of the World," refers to the Egyptian beer. Sophocles and Æschylus also. The latter, —

> "And after this he drank his beer, and much
> And loudly bragged."

Athenæus says that Thracians and Pæonians drank of barley-wine, or a similar drink made from millet or other grain.

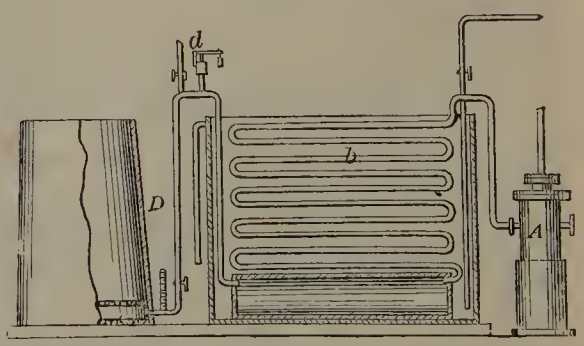
"Polybius describes the palace of one of the Spanish kings as being [furnished with] huge silver and gold goblets full of the wine made of barley." — ATHÆNEUS.

"Aristotle says that wine of grapes is stimulating, but that of barley has a tendency to stupefy." — *Ibid.*

Beer-cool'er. (*Brewing.*) *a.* A large shallow vat or cistern in which the beer is exposed to the air to cool.

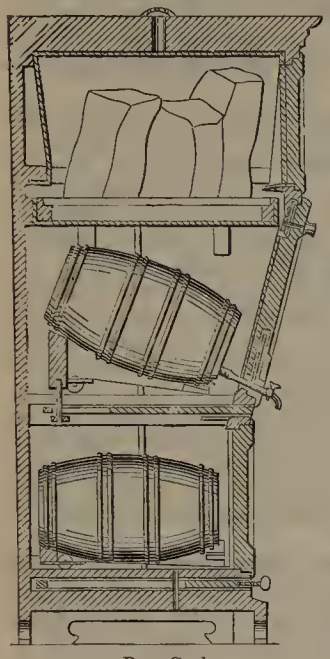
b. A tub or cistern in which beer is exposed to cooling influences mechanically exerted, as in Fig. 631, in which air is driven by the pump *A* through the worm *b*, which is in a cistern of ice-cold water,

Fig. 631.



Beer-Cooler.

Fig. 632.



Beer-Cooler.

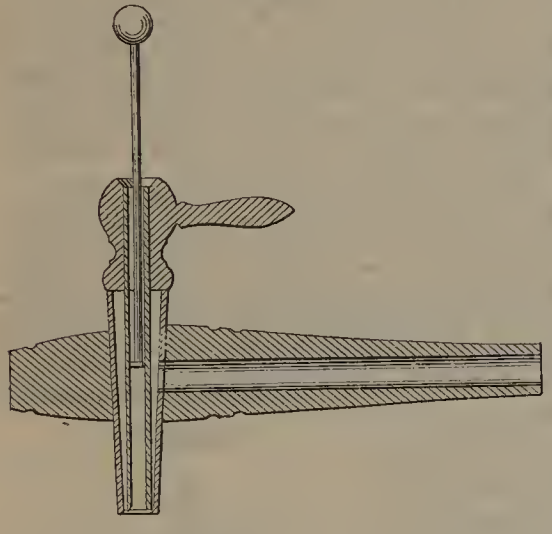
and escapes in jets through the beer in vat *D*. *d* is a safety-valve.

In another form the beer-vat has a jacket in which ice-cooled water circulates. The devices are numerous.

Fig. 632 shows a form of beer-cooler in which the kegs are kept in a refrigerator; the ice being in the upper chamber, the cooled air descends by gravity.

Beer-fau'cet. For draining certain descriptions of beer it is desirable to foam it, which is done, when the beer has not life enough of its own, by means of a piston which ejects air along with the beer into the glass or pitcher. As the piston descends, air is ejected at the central aperture, mixing with

Fig. 633.



Beer-Faucet.

the beer, which passes out at the annular orifice around the air-opening.

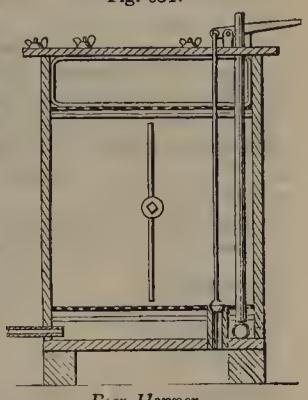
Beer-float. (*Distilling.*) An areometer or hydrometer designed to ascertain from the observed density of a grain-wash the possible yield of spirit therefrom. The scale of the instrument is graduated to indicate directly at the standard temperature the percentage by volume of proof-spirits that the mash will yield, provided the fermentation proceeds to a point where its density is equal to that of water.

Beer-foun'tain. A form of pump used in drawing beer into a glass for immediate consumption. It generally consists of a lever mounted in an ornamental stand, and connected to a piston in a pump which raises the beer from the cask and ejects it at the faucet by the lever.

Beer-hop'per. A vat or beck in which the infusion of hops is made, to be added to the wort.

The hops to be treated are placed upon the false bottom, and the liquor is then introduced, and steam let into the lower compartment. Pipes are provided for drawing off the liquid, preventing its overflow, and conducting the aroma. The stirring device is removable, to allow the false bottom to be taken out.

Fig. 634.



Beer-Hopper.

Beer-ma-chine'. A machine consisting of a number (say three to eight) of lift or force pumps, which connect with as many casks of different qualities of malt-liquor in a cellar, and are operated by oscillating handles in a neat case at the counter where the liquor is drawn. The faucets are arranged in a row over a sink which catches the drip. The affair is one of the polished appointments of a bar-room.

Beer-vat. (*Brewing.*) One in which the infusion of the malt is made, constituting the wort or sweet unfermented liquid, which, with the added infusion of hops and the resulting fermentation, becomes beer.

Bee'tax. (*Agriculture.*) An instrument for paring turf.

Bee'tle. 1. A heavy mallet or wooden hammer used in driving wedges, solidifying the earth, etc. Also called a *maul*. The handle is at right angles to and passes through the head, like a hammer; and, like the latter, receives a swinging motion, the shoulder being the center of vibration. The rammer, on the contrary, receives propulsion in the direction of its length, as the pavior's rammer, the ramrod, etc.

The beetle was used by the Greeks to bruise olives at the press.

The pavior's rammer is sometimes made so large as to be operated by several men. Perhaps it was to a large maul that Falstaff referred: —

> "If I do, fillip me with a three-man beetle."

2. (*Cotton.*) The *beetling-machine* formerly used in cotton-mills consisted of a long series of vertical stamps, lifted consecutively by studs set spirally on a horizontal rotating shaft, and coming down upon the cloth as it was wound upon a roller rotated slowly beneath. The action is similar to the ore-stamps of the mines.

Bee'tle-head. The weight or *monkey* of a pile-driver.

Beet-root Su'gar Ma-chin'er-y. The process consists in: —

1. *Washing* the roots in a rotating drum of laths submerged in a cistern of water.

2. *Rasping* to a pulp by a hollow studded cylinder, against which the roots are pressed, a jet of water keeping the drum clear of the pulp.

3. *Pressing* the pulp in woolen bags in a hydraulic press to remove the saccharine juice. Pecqueur substitutes a force-pump action and foraminated cylinders covered with wire-gauze. The cane-rolling mill has also been used.

4. The resulting juice is heated to 140°, defecated by hydrate of lime, filtered and evaporated in a vacuum-pan. See CONDENSER; EVAPORATOR; VACUUM-PAN; SUGAR-MACHINERY; DIFFUSION APPARATUS.

Maceration and *desiccation* have each been tried with some degree of success. The first notice we find of the making of beet-root sugar was in 1747.

Achard's (French) process made the manufacture a success in 1799.

Napoleon encouraged it when the English cruisers destroyed the commerce of France, and cut her off from her sugar-producing colonies.

It is now being tried in Illinois, Utah, and California.

Be-lay'ing-pin. (*Nautical.*) A stout pin in the side of a vessel or round the masts, used for fastening or *belaying* ropes.

There are several contrivances for belaying, differing especially in size. We may cite: —

Belaying-pin.	Cleat.
Belaying-cleat.	Kevel.
Belaying-bitt.	Riding-bitt.
Chess-tree.	

Bel'fry. 1. A warlike machine in the form of a tower, formerly used in sieges as a cover while firing on the enemy.

2. (*Architecture.*) *a.* A tower, either forming part of a building or detached, in which bells are suspended.

b. The apartment in a tower, etc., in which the bells are placed.

Bell. 1. *a.* A hollow, cup-shaped, metallic object suspended by a neck, and sounded by a swinging clapper.

b. A hollow, metallic sphere sounded by a loose ball in its interior.

Bells are of very great antiquity, small golden bells being mentioned in Exodus xxviii. 34, as forming, alternated with pomegranates, ornaments upon the hem of the high-priest's robe. Small bells, composed of an alloy of 10 copper and 1 tin, were found by Layard at Nimroud.

Bells (*tintinnabulum*) in ancient Greece and Rome were of various forms, hemispherical, pyramidal, sometimes like the modern flaring or the Chinese pattern. They also used flat disks, like gongs.

They were used for lustrations; frames with bells of varying sizes and pitch were used in religious observances. They were hung at the outer doors of houses, as often to notify passers that somebody was coming out as that some one awaited leave to enter, for the doors uniformly swung outward into the street. They were used to awaken the family or call them to meals (Seneca). They were used publicly in the camps and garrisons, on triumphal cars, and Plutarch alludes to their use in the fish-market; they were also carried by the night-watch. They were hung upon horses, cattle, and sheep, as with us, to trace them in case they should stray. According to Pliny, the monument of Porsenna was decorated with bells. Lars Porsenna, of Clusium, he who halted at the Tiber, was contemporary with Daniel.

After this statement it seems futile to simply repeat the legends of the introduction of bells into Europe in the fifth and sixth centuries, as if they were then a new thing.

Sheep-bells of bronze were used in ancient Italy, and are yet preserved in the Museum of Naples. Then, as now, the sheep made periodical migrations from their lowland winter pastures to their mountain summer pastures, like those subject to the code of laws "La Mesta" of Spain. See Merino. Varro refers to his flocks wintering in Apulia, but spending the summer on the mountains of Samnium.

Bells are said to have been introduced into Christian churches about A. D. 400 by Paulinus, Bishop of Nola, in Campania; into France about 550. They were mentioned by Bede, and are known to have been used in England prior to the year 700. Bells were first cast in England in the reign of Edmund, A. D. 940.

In A. D. 610, Clotaire II., king of France, besieged Sens, when Lupus, Bishop of Orleans, ordered the bells of St. Stephen to be rung. The sound so frightened Clotaire that he gave up the siege. So they say.

Pope John IX. ordered bells to be rung as a defence against *thunder* and lightning, A. D. 900.

All the bells in Europe were rung in 1456, by order of Pope Calixtus III., to scare away Halley's comet, which was supposed to be in some way identified with Mohammed II., who had just taken Constantinople. The comet left, but Mohammed stayed.

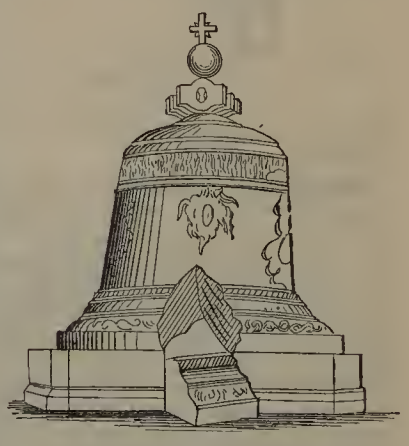
Most of the bells of Western Europe appear to have been hand-bells, of which some curious examples are still preserved. They are made of thin plates of hammered iron, bent into a four-sided form and brazed together at the corners. One of these, said to have belonged to St. Patrick, is preserved in the city of Belfast. For a long period they were made of comparatively small size. One in a church at Orleans, in the eleventh century, weighed 2,600 pounds, and was considered as remarkably large at that time.

During the thirteenth century much larger bells began to be cast. The "Jacqueline," at Paris, cast in 1300, weighed 15,000 pounds; one cast at Paris in 1472 weighed 15,000 pounds; and the bell of Rouen, cast in 1501, weighed over 36,000 pounds.

"One of the pieces in my collection which I the most highly value is the silver bell [made by Benvenuto Cellini] with which the Popes used to curse the caterpillars, — a ceremony, I believe, now abandoned. Lahontan, in his travels, mentions a like absurd custom in Canada, the solemn excommunication by the bishop of the turtle-doves, which greatly injured the plantations. For this bell I exchanged with the Marquis of Rockingham all my Roman coins in large brass. The rilievos, representing caterpillars, butterflies, and other insects, are wonderfully executed." — Horace Walpole.

The bell known as the "Liberty Bell," which, on the 4th of July, 1776, announced the signing of the Declaration of Independence, was cracked while being rung in honor of the visit of Henry Clay to Philadelphia, and since then has been on exhibition in that city, together with other Revolutionary relics. The following inscription, taken from Leviticus xxv. 10, surrounds it near the top: "Proclaim liberty throughout the land, unto all the inhabitants thereof."

Fig. 635.



Great Bell of Moscow.

The Russians have surpassed all other European peoples in the size of their bells. The great bell of Moscow, cast by the orders of the Empress Anne in 1734, was by far the largest made by them, being 21 feet in height, and weighing 193 tons. It remained suspended only until 1737, when it fell in consequence of a fire, and remained partially buried in the earth until 1837, when it was raised, and now forms the dome of a chapel formed by excavating the earth

underneath it. It has been denied that this bell ever was suspended.

Says a correspondent of the "New York Observer": "In Russia the bell is an instrument of music for the worship of God as truly and really as the organ in any other country. This is the key to what would otherwise be difficult to explain.

"The bell is a medium of communication with *the Infinite*, and the worship of a people and an empire finds expression in the majestic tones of a bell, and it ceases to be a wonder that a bell should have a tongue which requires twenty-four men to move, and whose music sends a thrill of praise into every house in the city, and floats away beyond the river into the plains afar.

"Moscow is the 'holy city' of the Greek Church. Pilgrims come hither from thousands of miles off, and on foot, and sometimes without shoes. When they draw near the city, and on the evening air the music of these holy bells is first borne to their ears, they fall upon their faces prostrate, and worship God. If they could go no farther, they would be content to die there, for they have heard the bells of Moscow, and on their majestic tones their souls have been taken up to heaven! This is the sentiment of the superstitious peasant, and it is a beautiful sentiment, — ideal, indeed, but all the more delicate and exalted. *We* use the bell simply to call the people to the house of worship; they speak to us. *Their* bells praise God. They cast their silver and their gold into the molten mass, and it becomes an offering, as on an altar, to Him who is worshipped with every silvery note and golden tone of the holy bell.

"Ascending the Ivan tower, we find on three successive stories bells to the number of thirty-four. Some of these are of a size to fill one with astonishment had he not seen the giant below. The largest is on the first story above the chapel, and weighs more than 127,830 pounds. It swings freely and is easily rung. I smote it with the palm of my hand, supposing that such a blow could not produce the slightest vibration in such a mighty mass of iron; but it rang out as clear and startling as if a spirit within had responded to my knock without. Two bells are of solid silver, and their tones are exquisitely soft, liquid, and pure. It was exciting to go from one to another and strike them with their tongues or with your hand, and catch the variety and richness of their several melodies.

"I had come down from the Kremlin to my lodgings, and, wearied with the wanderings of the day, was lying on the bed and looking out on the city. It is just before sunset, and the day has been oppressively warm. A delicious glow from the gorgeous west is bathing all the domes and roofs with splendid colors, and silence is stealing in with the setting sun upon the crowded city. It is the eve of one of the most holy festivals of the Greek Church. One vast church edifice is directly in view of my window, and but a short way off.

"As I lie musing, from this church near at hand comes the softest, sweetest tone of an evening bell. Another tone responds. A third is heard. The Ivan tower on the hight of the Kremlin utters his tremendous voice, like the voice of many waters. Then all the churches and towers over the whole city, — four hundred bells or more, — in concert, in harmony, 'with notes almost divine,' lift up their voices in an anthem of praise such as I never thought to hear with mortal ears, waves of melody, an ocean of music, deep, rolling, heaving, changing, swelling, sinking, rising, sounding, overwhelming, exalting."

"Keeping time, time, time,
In a sort of Runic rhyme."

The Chinese have likewise produced bells of colossal size, one of which, at Pekin, weighs 130,000 pounds; but the tone of their bells is said to be discordant and "panny," like that of their gongs.

The great bell of Burmah, at a temple in the environs of Amarapoora, is slung on a triple beam cased and hooped with metal, and resting on piers of brickwork. In the upper part are visible the chains of iron around which the metal of that portion was run, to strengthen it at the point of suspension.

Its dimensions are as follows: —

External diameter at the lip	16 feet 3 inches.
External diameter 56 inches above the lip	10 "
Interior hight	11 " 6 "
Exterior hight	12 "
Interior diameter at top	8 " 6 "
Thickness	6 to 12 "
Weight, about	260,000 pounds.

Klaproth states that in an edifice before the great temple of Buddha, at Jeddo, is the largest bell in the world.

"It is 17 feet 2⅓ inches in hight, and weighs 1,700,000 pounds English. Its weight is consequently nearly four times greater than the great bell at Moscow, and 56 times larger than the great bell at Westminster, England."

The bell suspended from a tripod and hand-bells are regular accessories in Japanese bands, if such they may be termed.

As among the Slavonic nations, the bell is the great musical feature of Tartarian worship: —

"The Lamas execute a kind of music little in concord with the melodious gravity of the psalmody. It is a stunning noise of bells, cymbals, tamborines, conch-shells, trumpets, whistles, etc." — Abbé Huc, *Travels in Tartary*.

The Chinese and Mandshu words for bell are onomatopoetic, being respectively *tsiang-tsiang* and *tang-tang*.

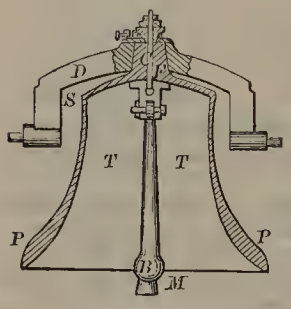
The weight, dimensions, and date of casting, of some of the largest bells in the world are stated to be as follows: —

	Weight. Pounds.	Diameter. Ft. In.	Thickness. Inches.
Moscow (Kremlin),			
Cast in 1553	36,000		
Cast in 1654	288,000		
Fell in 1703.			
Recast in 1733	432,000	21.	23
Broken in 1737.			
Moscow (St. Ivan's)	127,830		
Burmah (Amarapoora)	260,000		
Pekin	130,000		
Novogorod	62,000		
Vienna (1711)	40,200	9.8	
Olmutz	40,000		
Rouen	40,000		
Sens	34,000	8.6	
Erfurth	30,800		
Westminster ("Big Ben," 1858)	30,324		
London (Houses of Parliament)	30,000		
Paris (Notre Dame, 1680)	28,672	8.6	7½
Montreal (1847)	28,560	8.6	8¼
Cologne	25,000		
New York (City Hall)	23,000	8.	6½ to 7
New York (Fire-alarm, 33d Street)	21,612		
York ("Great Peter," 1845)	10¾ tons.	8.3	

	Weight Pounds.	Diameter. Ft. In.	Thickness Inches.
Bruges . . .	23,000		
Rome (St. Peters, 1680)	18,600		
Oxford ("Great Tom," 1680) . . .	18,000	7.1	$6\frac{1}{8}$
Antwerp . .	16,000		
Exeter (1675) . .	$5\frac{1}{2}$ tons.	6.3	5
Lincoln ("Great Tom," 1834) . . .	$5\frac{1}{2}$ tons.	6.8	6
London (St. Paul's, 1709)	11,470	6.7	

Fig. 636 represents a bell having a rotatable clapper. The various parts are —

Fig. 636.



Bell.

B, clapper or tongue.
C, clapper-bolt.
D, yoke.
F, canon or ear.
M, mouth.
P, sound-bow.
S, shoulder.
T, barrel.

Cattle and *sheep* bells are cast, or are made of wrought-metal by being doubled over at the angles or cutting and brazing. Each carries its clapper.

Harness and *sleigh* bells are sometimes made as others, with a suspended clapper in the usual bell-shaped article, but are generally hollow spheres with perforations, and contain globes of iron which have free play and give a sharp jingle rather than a sonorous and prolonged note.

Call bells are used for the table or desk to summon a servant or messenger in the vicinity.

Chimes, or peals of bells, are of very ancient date, the first chime introduced into England having been put up at Croyland Abbey, A. D. 960, and to this day that country is noted for the number and variety of its peals of bells, which are an institution of almost every village church.

The making and arrangement of a suit of bells to constitute a perfect chime is a matter of considerable difficulty. The tone of a bell depends conjointly on its diameter and thickness, a small or thick bell yielding relatively a more acute sound than one which is larger or thinner, owing to the greater rapidity of the vibrations of the metal. The founder endeavors to regulate the diameter and thickness so as to produce a certain note in each bell of a set of chimes; but as this is difficult to be attained by the mere operation of casting, it is generally necessary to remove some of the metal afterwards to produce a perfect note, by either reducing the diameter at the lower edge when the note is too low, or reducing the thickness of the part struck by the clapper when too sharp. See CHIME.

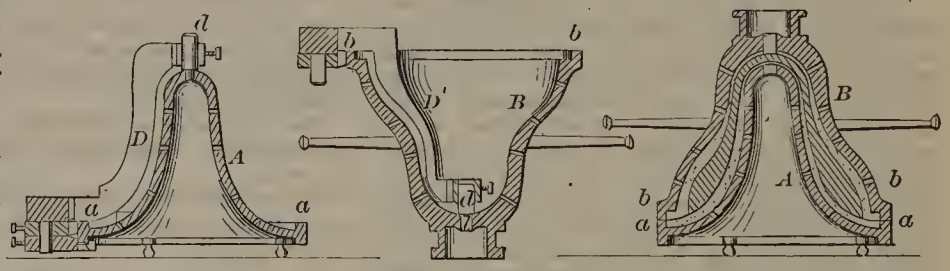
The thickest part of the bell is that struck by the clapper, and is called the *sound-bow*. Among the German bell-founders this is taken as the unit of construction, and being considered as = 1, the most approved proportions are: diameter at the mouth, = 15; diameter at the top, = $7\frac{1}{2}$; hight, = 12; and the weight of the clapper = $\frac{1}{40}$ of the weight of the bell.

The casting of small or house bells is performed in a manner similar to that of other small brass or bronze castings; but with the larger bells, furnaces capable of melting large quantities of metal are required. For very large bells the mold is usually constructed in a pit in the vicinity of the furnace. The core is rough brick-work covered with layers of clay and horse-dung, turned to shape by a templet. This being dried, a "model" of earth and hair is laid on, being the exact counterpart of the future bell. A third and heavy shell is laid over the model, and when dry is lifted from the model, some *parting* dust having been sprinkled over the model before applying the material of the outer shell. The model is now cut away from the core and the shell replaced, leaving a space between the shell and the core the exact form and size of the bell. The pit being filled around the shell, the metal is run into the mold.

Fig. 637 shows a device for molding bells. The templets or *sweeps D D'* each turn on a guide-pin *d*, passing through an opening in the inner and outer cases *A B* respectively, which have lips *a b* around their lower peripheries, serving as guides to the sweeps, and also relieving the loam-mold from pressure when the two cases are brought together.

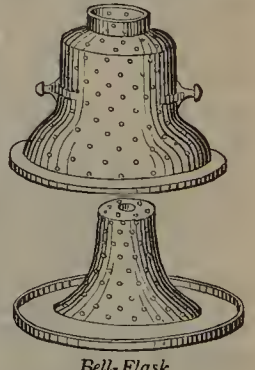
The molds previously described do not afford adequate provision for the escape of confined air and gases, and the casting is liable to be porous. An improved method consists in the employment of perforated metallic flasks corresponding to the interior and exterior surfaces of the bell, and accurately centered to each other by a vertical guide. The outer flask is coated internally, and the inner one externally, with a mixture of loam and combustible matter. The combustible matter is burnt out by the heat of the molten metal, allowing this to shrink, and preventing the occurrence of what is known as a fire-crack or strain; and, the perforated flasks being above ground, free escape is permitted to the gases.

Fig. 637.



Bell-Mold.

Fig 638.



Bell-Flask.

This arrangement is shown in Fig. 638.

2. The mouth of a funnel or trumpet. The *pavillon* (Fr.).

Bell-buoy. (*Nautical.*) One to which a bell is so attached as to be rung by the motion of the waves.

Bell-crank. (*Machinery.*) A rectangular lever having its fulcrum at the apex of the angle, by which the direction of a motion is changed 90°. Its pri-

Fig. 639.

Bell-Crank.

mary application was for ringing bells, hence the name; but it is applicable to many other purposes where a power is to be exerted upon a weight in a direction of 90° from it.

Bell-glass. (*Glass.*) A bell-shaped glass vessel, open at bottom, and having a knob on top for convenience of handling. It is used in connection with an air-pump, by which the air may be exhausted from it; also for holding gases to be experimented upon.

Bell-met'al. An alloy composed of copper and tin, either alone or with the addition of a greater or less proportion of other metals, usually zinc and lead. It is a species of bronze, and from its hardness and sonorousness is better adapted than any other metal for the purpose from which it derives its name. 75 parts copper to 25 tin is a usual proportion, but its constituents vary from 50 copper, 33 zinc, and 17 tin, to 80 copper, 10 tin, 6 zinc, and 4 lead; sometimes the proportions 72 copper, 26.5 tin, and 1.5 iron have been employed. The proportion 78 copper to 22 tin is generally recognized in commerce.

Other approved proportions are given below.

	Copper.	Tin.	Iron.	Zinc.
For Indian gongs . . .	100	20–25		
Church and large bells .	3	1		
House and hand bells . .	2	1		
Paris clock bells . .	72	26½	1½	
Clock bells	72	26		2
Repeating-watch bells .	70	26		4
Overman's	71	26	1	2
Ancient Assyrian bells .	86	14		

"In some cases two metals were used without alloying; iron, for instance, being overlaid partially or wholly with bronze." — LAYARD.

Bel'lows. (*Pneumatics.*) A device for forcing a stream of air, usually as a means of urging a fire.

Bellows were used in Egypt in the time of Thothmes III., 1490 B. C., and are represented on a tomb bearing the name of that Pharaoh.

A pair of leathern bags or cylinders, attached to disks, were alternately inflated and compressed, during the latter action driving air by a pipe to the fire. The cut is from the tomb referred to, and the

Fig. 640

Egyptian Bellows (Thebes).

men are shown working the bellows with the feet and hands, throwing the weight on the bags alternately, and lifting with a cord the one which is just exhausted; the other man is holding the rod of metal in the fire. The oldest form of wind-bag was probably the skin of an animal sewed up, or else a wooden reed with a piston like that of a popgun, until tubes were bored out of wood or made of a ring of bark taken from a tree. Our common bellows, consisting of two boards joined by a piece of leather, was early known to the Greeks and Romans. See Fig. 145.

In the *Spiritalia* of Hero, 150 B. C., is described a steam-boiler from which a hot-air blast, or hot air mixed with steam, is blown into the fire, and from which hot water flows, or cold is introduced.

Double foot-bellows, and duplicate pipes to the iron furnace, with four tuyeres, are shown in the paintings of Kourna, Thebes. The blow-pipe and tongs in connection with a smelting-furnace in the same place.

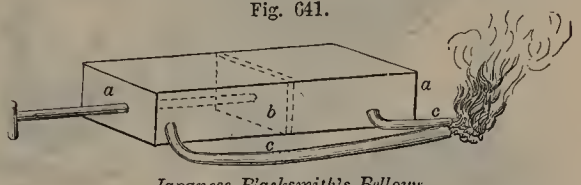
The mention of the burning of the bellows in Jeremiah vi. 29, seems to have been in connection with lead and silver smelting and refining. This is a common combination of metals in ores.

Strabo ascribes the invention of the bellows to Anacharsis the Scythian, who was coëval with Solon. The anchor and the potter's wheel are also ascribed to this man by Pliny, Seneca, and other Romans; the declaration, however, is quite inadmissible as to the potter's wheel, and equally untrue as to both the bellows and the anchor. Homer mentions the potter's wheel, and it was used in Egypt one thousand years before Homer. On the walls of the tombs of ancient Egypt are painted, Ptah, the Creator, and Neph, the Divine Spirit, sitting at the potter's wheel turning clay to form men.

Among the ancient forms of bellows may be cited:

Skins of animals sewed up to form bags, and used in a manner analogous to the bellows of the bagpipe.

Fig. 641.



Japanese Blacksmith's Bellows.

Two such skins used alternately would give a continuous blast: such was the ancient Roman forge-bellows.

A pair of hollow cylinders, made of bamboo or hollow logs, and having pistons actuated by manual power.

A pair of large calabashes connected by two reeds, and having large openings at the top, covered by tubes of soft goatskin, which are closed down alternately.

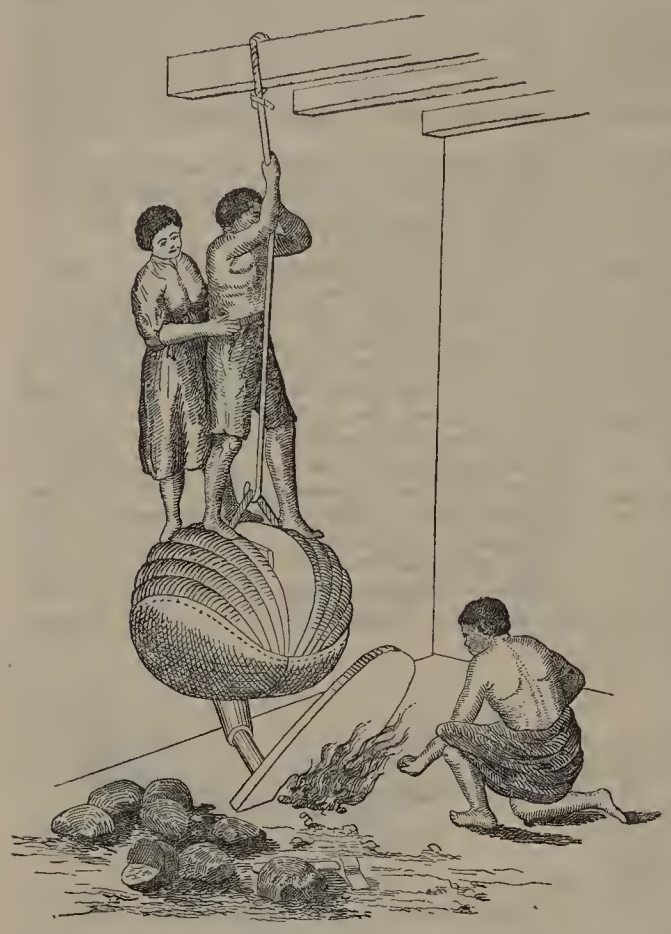
A cylindrical bag of soft skin closed at the ends by two wooden disks, by which it was opened and closed like a Chinese lantern. This device in its duplicated form, to render the blast continuous, is still used in Europe and South America.

The Japanese bellows consists of a box *a*, with a reciprocating piston *b*, and two eduction-tubes *c c*, leading from the respective ends of the box to the fire. Our illustration does not indicate the valves in the tubes to prevent reflux of air, nor the air-induction openings. The artist leaves them to be supposed, which is not difficult to do.

The smelting of the ferruginous sand of the Nonkreem Valley, on the confines of English India, is very rudely carried on in charcoal fires blown by double-action bellows, worked by two persons, who stand on the machine, raising the flaps with their hands and expanding them with their feet, as shown in the cut. There is neither furnace nor flux used

in the reduction. The fire is kindled on one side of an upright stone (like the head-stone of a grave), with a small arched hole close to the ground; near this

Fig. 642.



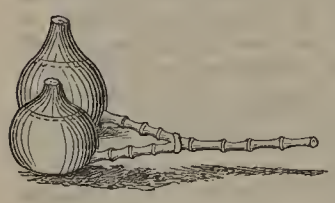
Nonkreem Bellows.

hole the bellows are suspended; bamboo tubes from each of its compartments meet in a larger one, by which the draft is directed under the hole in the stone to the fire.

The ore is run into lumps as large as two fists, with a rugged surface; these lumps are afterward cleft nearly in two to show their purity.

Fig. 643 shows a bellows employed by the Foulah blacksmiths on the west coast of Africa. It consists of two calabashes connected together by two hollow bamboos or reeds inserted into their sides and united at an angle to another which leads to the fire. A large opening is made in the top of each calabash, and a cylindrical bag of soft goatskin stitched or otherwise secured around the edges. The workman seats himself on the ground, and, placing the machine between his legs, grasps the ends of the bags, and by alternately raising each with the mouth open and pushing it into the calabash when closed, the contained air is forced into the tubes and a continuous blast maintained.

Fig. 643.



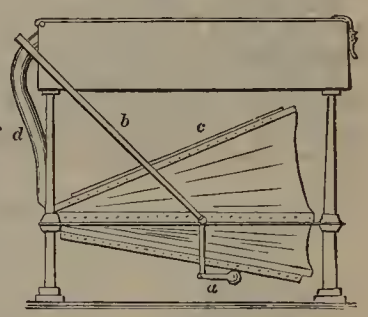
Foulah Bellows.

Wooden bellows were known in Germany in the middle of the sixteenth century, but it is not certain by whom they were invented. Lobsinger of Nuremberg (1550), and Schelhorn of Schmalebuche, in Coburg (1630), are cited as having introduced them.

They are described in a work by Reyner, professor at Kiel, 1669, as being "pneumatic chests," and as consisting essentially of a lid moving in a closely fitting box. In another form we find that two boxes were used, one fitting closely within the other, and the two, being perhaps quadrantal segments of cylinders, were hinged together so that the movable one vibrated on the common axis.

The ordinary bellows in its simplest form consists of two flat boards, usually of triangular shape, each having a projecting handle; and between the boards are two or more hoops bent to the figure of the bellows. A piece of leather is nailed to the edges of the boards, partially infolding the hoops, and forming an inclosed chamber, which is enlarged or contracted by raising the upper board while the lower one remains stationary. The lower board has a metallic pipe attached and a valve in its center, opening upward, which rises when the upper board is raised, admitting air into the chamber, which is expelled through the pipe by depressing the upper board; this arrangement does not afford a continuous blast, the air issuing in puffs, and accordingly the smith's bellows is furnished with a third board, of the same shape as the other two, connected to the lower board by a piece of leather, and dividing the bellows into two similar chambers connected by a valve opening upward; the blast-pipe is connected to the middle board, issuing from the upper chamber. The lower board is held down by a weight, and a weight is also attached to the upper board. In working the bellows the middle board is raised, drawing the air through the valve into the lower cavity, and the descent of the board forces it into the upper cavity, the valves preventing its return, and the weight, depressing the upper board, forces the air out through the pipe in a continuous blast; the ascent of the middle board fills the lower cavity, while its descent fills the upper cavity, the irregular puffing action being confined to the lower cavity of the bellows; the

Fig. 644.



Forge-Bellows.

Fig. 645.

Old Roman Lamp.

blast is however, though continuous, not quite regular, as, when the air is forced into the upper cavity, there is an excess of pressure over the pressure during the descending motion of the lower board.

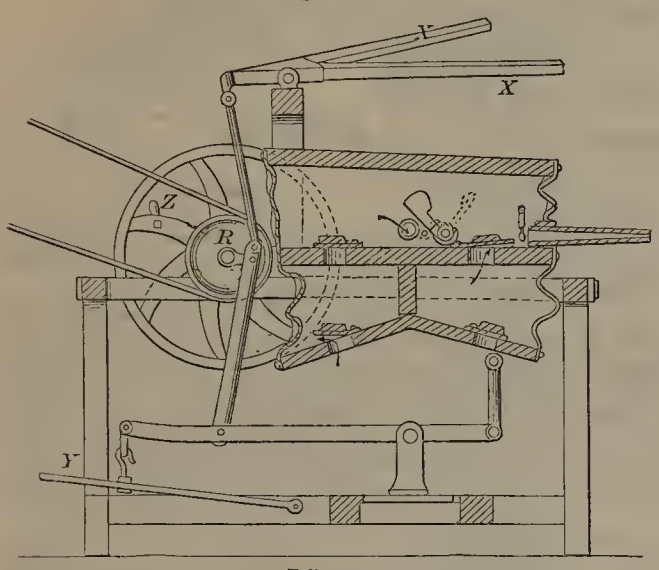
The smith's bellows is worked by means of a rocker with a cord, chain, or rod attached. By drawing down the handle *b* of the rocker the movable board rises, forcing the air through the valve into the upper chamber; the weight on the board *c* forces the air out through the pipe *d* to the fire on the forge-hearth.

Fig. 645, from an ancient Roman lamp, is an exact counterpart of the modern domestic bellows.

Various machine-worked bellows have been invented, but generally those which rise to the dignity of machines lose the pulsative character and have come to be called blowers.

In Fig. 646 the V-shaped bottom is pivoted in the middle, and has a rocking motion imparted by lever

Fig. 646.



Bellows.

X, treadle *Y*, or pulley with fly-wheel *R Z*, either affording a continuous blast. See also BLOWER; BATTERY-FORGE, etc.

A blowing-engine in which the blast of air is supplied by a falling column of water.

Fig. 647.

Bellows-Pump.

Bel'lows-cam'e-ra. (*Photography.*) A form of expanding camera in which the front and after bodies are connected by an expansible portion, like the sides of a bellows or accordeon.

Bel'lows-pump. (*Hydraulics.*) A form of atmospheric pump in which the part of the piston is played by the upper leaf of the bellows. The cut is from Vegetius; Erffurt, 1511.

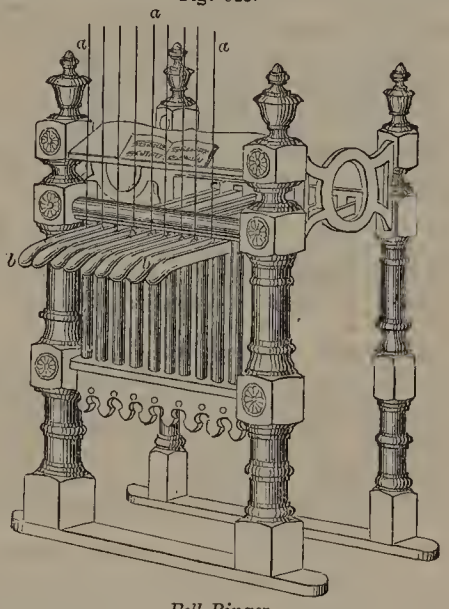
The *bag*-pump and *diaphragm*-pump are other forms.

Bell-pull. The knot and attached cord, or series of wires and bell-crank levers, by which a house-bell is caused to strike.

Bell-ring'er. In England each bell of a chime is provided with a yoke and wheel, and is oscillated in the usual manner, a ringer being required for each bell.

In this country they are usually mounted stationarily, except the tenor, and rung by means of cords

Fig. 648.



Bell-Ringer.

attached to the clappers and led to the ringer's room below, where they are connected, in the order of the notes, with lever-handles *b*, so arranged that the bells may all be chimed by one person. The tenor-bell is provided with mountings for swinging, in order that it may be rung as an ordinary church-bell, and is usually placed in the center of the bell-room, the others being grouped about it in such relative positions as will most advantageously distribute the weight and allow the best arrangement of the ringing-cords.

Among the devices for the mechanical ringing of bells may be cited steam acting upon a piston to vibrate the clapper; air acting upon vanes to move a pitman connected to the clapper or the axis of the bell; springs released to cause a certain number of pulsations to give a specific alarm set in operation by the touch of a trigger. See CHIME.

Bell-tel'e-graph. A form of apparatus invented by Sir Charles Bright, in which the signals are given by strokes upon two bells of different pitch, one of which represents the movements of the needle to the left and the other to the right.

Bell-trap. (*Pneumatics.*) One form of air or stench trap to prevent the reflux of foul air from drains. It consists of an inverted cup whose edges are submerged in the water of a basin which overflows into the drain. This permits an overflow of water, but prevents a reflux of air. See AIR-TRAP.

Bel'ly. The front or lower surface of an object; as —

(*Railway Engineering.*) The belly of a railway rail; a descending flange between bearings.

(*Music.*) The front of a musical instrument.

(*Engraving.*) The lower edge of a graver.

(*Wheelwrighting.*) The wooden covering of an iron axle.

The rounded surface of an object; as of a bottle, retort, etc.

(*Metallurgy.*) The upper, rounded part of the boshes.

(*Architecture.*) The batter of a wall.

(*Nautical.*) The swell of a sail.

(*Shipwrighting.*) The hollow of a compass-timber; the convexity of the same is the *back*.

(*Machinery.*) A swell on the bottom surface of anything; as, a depending rib beneath a grate-bar, iron beam, or girder, to strengthen it from downward deflection between supports.

(*Saddlery.*) A piece of leather attached to the back of the cantle, and forming a point of attachment in some saddles for valise-straps.

The unburnt side of a slab of cork.

(*Locksmithing.*) The lower edge of a tumbler against which the bit of the key plays.

Bel'ly-band. 1. (*Saddlery.*) The strap which goes beneath the belly and is buckled to the ends of the back-band, completing the girth.

2. (*Nautical.*) A strengthening strip of canvas half-way between the close-reef and the foot.

Bel'ly-brace. (*Steam-Engine.*) A cross-brace stayed to the boiler between the frames of a locomotive.

Bel'ly-rail. (*Railroad Engineering.*) A railroad rail with a fin or web descending between the portions which rest on the ties. It is seen in the improved Penrhyn rail, 1805; also in Stephenson and Losh's Patent, 1816.

Bel'ly-roll. (*Agriculture.*) A roller with a protuberant midlength, to roll the sloping sides of adjacent lands or ridges.

Belt. 1. (*Machinery.*) A strap or flexible band to communicate motion from one wheel, drum, or roller, to another. Belts are made of leather, gutta percha, caoutchouc, wire, woven fabric, and other materials.

Two leathern belts have lately been made in Pawtucket, composed of two thicknesses of leather firmly cemented together, without a stitch, rivet, or peg in either of them, and are half an inch thick. The larger of the two was made from 54 large ox-hides, is 136 feet long, 48 inches wide, and weighs 1,000 pounds. The other is 87 feet long, 36 inches wide, and weighs 475 pounds.

The ratio of friction to pressure for belts over wood drums is, for leathern belts, when worn, .47; when new, .5; and when over turned cast-iron pulleys, .24 and .27.

A leathern belt will resist a strain of 350 pounds per square inch of section, and a section of .2 of a square inch will transmit the equivalent of a horse-power at a velocity of 1,000 feet per minute over a wooden drum, and .4 of a square inch over a turned cast-iron pulley.

A vulcanized india-rubber belt will sustain a greater stress than leather, added to which its resistance to slipping is from 50 to 85 per cent greater.

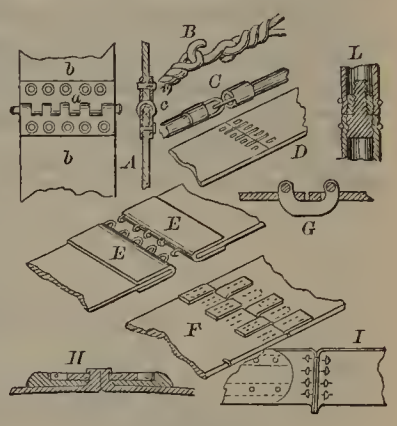
2. (*Masonry.*) A range or course of stones or bricks projecting from the rest, either plain or fluted.

Belt-clasp. (*Joint.*) A device for attaching the ends of belting together so as to form a continuous band. See BELT-COUPLING.

Belt-coup'ling. (*Machinery.*) A device for joining together the ends of one or more bands or belts. This is commonly effected by cutting or punching holes near the two extremities to be joined, and lacing them together by thongs of lacing-leather or calfskin. Many special devices have been contrived to dispense with lacing, for which see also BUCKLE.

In the figure, *A* represents a coupling in which the ends of the belt *b* are secured by eyelets or rivets between bent metallic straps *a*, which form leaves of a hinge *c*. A pintle passes through the eye of each portion of the hinge.

Fig. 649.



Belt-Coupling.

For the round belts of foot and hand lathes, a figure-8 hook *B* is used for a coupling, or a couple of sockets *C*, into which the ends of the belt are inserted, and which have a hook and eye respectively.

For flat belts in which lacing is not deemed advisable, the ends may be joined by hooks inserted from alternate sides and hammered flat as at *D*.

Other modes of coupling-belts are to be found; some involving hooks *E*, and others lapping-plates *F*. Other forms approach the buckle and various peculiar interlacing devices, such as curved bars of metal *G*, slotted plate and toggle-jaws *H*, or rivets which pass through the out-turned end of the belt, as at *I*.

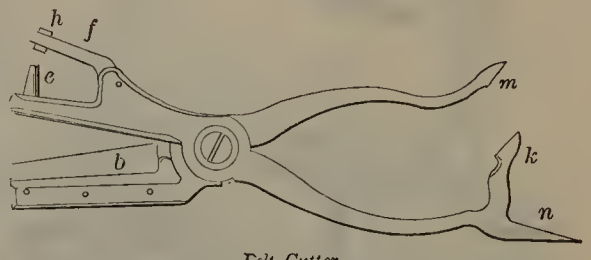
L is a tie in which a plug with two grooves is made the means of connection; the belt is tubular, and the respective ends are throttled by wires into the grooves of the plug.

Belt-cut'ter. *a*. A machine or tool for slitting tanned hides into strips for belting. In a machine for this purpose the knives are set at gaged distances apart, or the knife at a gaged distance from the governing edge, and the leather passed along below the knife, or conversely.

b. A tool for this purpose has a fence which runs along the governing edge, and a cutter adjustable to the required distance, equal to the width of the strip desired. Such tools are used by harness-makers for cutting out lines and straps for harness. See GAGE-KNIFE.

c. An implement for preparing belts for being laced

Fig. 650.



Belt-Cutter.

or coupled. That shown combines a cutting-blade *b*, punch *c*, awl *n*, and pliers *k m*.

Belt'ing. (*Machinery.*) A flexible band for communicating motion. See BELT.

Belts are made of leather, india-rubber, gutta-percha, hempen rope, webbing, etc.

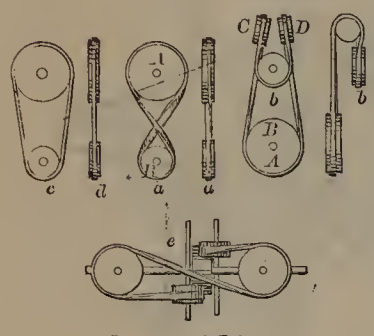
A belt is said to be *quartered* when it passes around pulleys whose axes are at right angles to each other, as at *b*.

Belts crossed so as to run the pulleys in opposite directions are said to be *crossed* or *halved* (*a*, Fig. 651).

A *band* is a flat belt.

c d (Fig. 651) are respectively side and end elevations of a driving and driven pulley, moving in the same direction, the relative speed being proportionate to their respective radii.

Fig. 651.



Drums and Belts.

a shows the belt crossed, causing the driven pulley *B* to move in a direction opposite to that of the driver *A*.

In *b b* two pulleys *C* and *D*, driven immediately from *A*, are caused to rotate in reverse directions by means of a guide-pulley *B*, under which the band passes.

e shows a mode of driving two pulleys from a single driver by one belt.

India-rubber belting is prepared by folding rubber cloth to a sufficient thickness and desired width. The folded stuff is then placed in a *flat-press*, and subjected to a steam-heat of 280° Fahr. to vulcanize the rubber and blend all the plies into one.

Artificial-leather belting is made of leather scraps and shavings washed in alkaline water, pulped with gelatinous and resinous substances, vegetable fiber, and bullock's blood.

When properly pulped, the same may be run off on an ordinary paper-machine or between rollers, and doubled to a proper thickness, and may be used either with or without farther preparation by japanning, stitching, or water-proof applications. The belting is usually subjected to a high temperature of heat, to set the gluten and other resinous properties.

A form of belting called *angular belting* has been lately introduced, which has riveted on the working side of the continuous plies of the belt a series of rectangular truncated pyramids of leather. The sides of the pyramidal frustums have an angle of about 60° with the belt in the example at the American Institute Fair, 1872; but this would probably vary with the diameter of the pulley over which these *belt-shoes* were designed to be lapped.

Leather belting is ordinarily prepared in the following manner: both oak and hemlock bark are used in tanning, but oak-tanned leather is decidedly superior, and commands a higher price in the market.

Slaughter hides are limed and bated in the usual way, closely trimmed and green shaved, after having been well washed in the washing-wheel, and when the hair has been removed they are put into the tan liquor, being tacked to laths which rest upon ledges along the sides of the vat.

After the tanning process has been completed, each hide is split into four pieces, of which the middle piece, comprising the back, is for heavy belting. These pieces are now put into the barrel-washer, and, after a few revolutions, for the purpose of cleaning them, they are passed between two iron cloth-covered rollers, constructed similarly to a clothes-wringer, by which they are pressed dry enough to receive the stuffing, the work being done by hand; the pieces are then hung up to dry.

When the stuffing has had time to dry in sufficiently, each piece is thoroughly dampened and then passed through a powerful lever-stretching machine, where it may be subjected to a strain of sixty tons to the piece, after which it is oiled and hung up to dry. The effect of this stretching is to make it almost impossible for the belt to stretch by ordinary use after completion.

These pieces, after becoming thoroughly dry, are passed to the belt-room, where are machines for planing off the laps, joining the different parts, and straightening the edges. After the riveting, the edges are pared or rounded, and for this purpose the belt is passed between two paring-bits, which are set one on each side of a groove the width of the belt. As the belt is drawn along the edges are rounded, the belt being wound around an arbor. If a square edge is required, the coil is simply taken from the arbor, scraped with a slicker, and burnished until it has a glazed appearance.

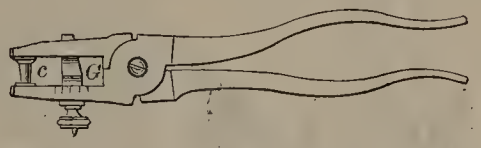
Belt-lac'ing. Leather thongs for lacing together the adjacent ends of a belt to make it continuous.

Machines for cutting narrow strips of leather for lacing operate by means of a gang of circular knives, which split into strips the leather which passes against them. The knives are secured by collars on a mandrel, at gaged distances apart, and their edges cut against a parallel roller set over against the former at such distance as may suffice to allow the leather to pass in the interval. Another form of the machine is a gang of stationary knives which cut the side or strip of leather which is drawn against and between them by means of rollers.

Belt-pipe. (*Steam-Engine.*) A steam-pipe which surrounds the cylinder.

Belt-punch. A punch for forming the holes in a belt into which lacing, rivets, or clasps are inserted. The punch *c* acts against an anvil on the other jaw,

Fig. 652.



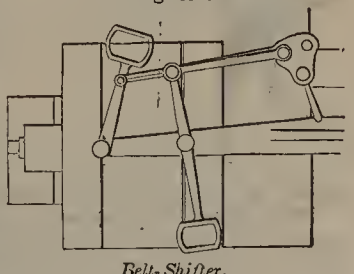
Belt-Punch.

the latter is graduated, and has an adjustable gage *G*, which may be set at such a distance from the nose of the pliers that a row of holes may be readily punched at a set distance from the edge of the belt.

Belt-saw. A BAND-SAW (which see).

Belt-shift'er. (*Machinery.*) A device for shifting a belt from a fast to a loose pulley, or *vice versa*, or from one pulley to another, to cause a change in the motion of the belt, or to shift the power of the belt to another pulley running in the same direction. In the illustration, the pivoted levers connected by jointed rods with the rocking-bar simultaneously shift the belts.

Fig. 653.



Belt-Shifter.

Belt-speed'er. (*Machinery.*) A pair of cone-

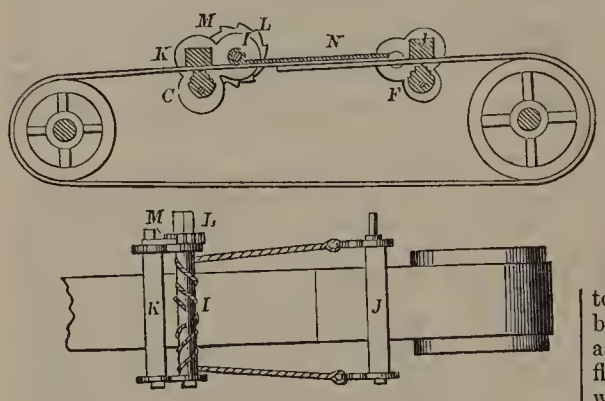
pulleys carrying a belt which, by shifting, become the medium of transmitting varying rates of motion. It is much used in some spinning-machines to vary the rate of rotation of the spool as the cap increases in size. See CONE-PULLEY.

Belt-splic'ing. (*Machinery.*) A mode of fastening ends of belts or belt-lengths, by splitting one end so as to hold the long tapered edge of the other one, which is cemented between the lips of the former.

Belt-stretch'er. A device for drawing together the ends of a belt, in order that they may be sewed or riveted to render the belt continuous.

The belt is placed around a couple of pulleys, and its ends approached to lap upon each other for sewing. The stretcher consists of a pair of clamps *K C*, *J F*, and a tightening-cord *N*, the leather in each clamp being pinched by a serrated eccentric. The rope winds upon the roller *I*, the pawl *M* engaging the ratchet *L* to maintain the stretch.

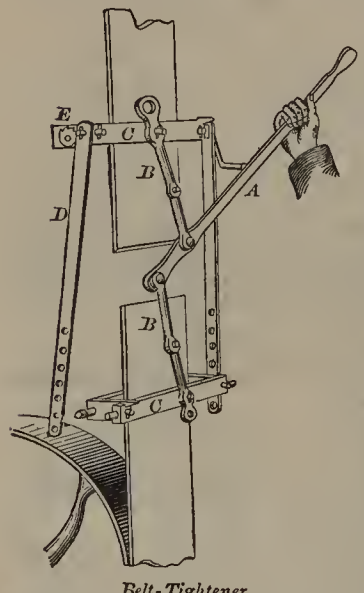
Fig. 654.



Belt-Stretcher.

Belt-tight'en-er. Fig. 655 shows a double clamp and a tightening-device, in which *A* represents a lever acting through toggles *B* to draw the clamps *C* towards each other. When they are drawn as nearly together as may be requisite, they are held by the bars or link *D* until the belt is laced or riveted.

Fig 655.



Belt-Tightener.

Another form of belt-tightener is a device to rest against the belt in some part of its length between two drums over which it runs, so as to increase its frictional adherence to the drums. The device is usually an idler-pulley on a swinging frame or weighted.

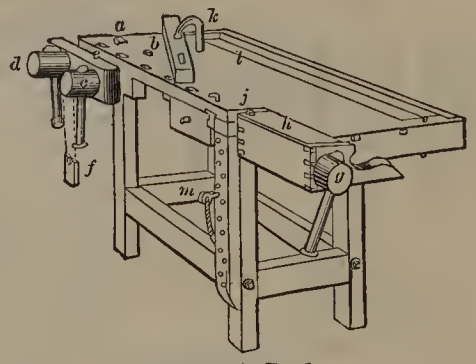
Belt-weav'ing Loom. One for weaving heavy narrow stuff suitable for making belts for machinery. It does not differ in any substantial respect from a narrow-ware loom, as belting only differs from webbing in proportions or material, if at all.

Bench. 1. (*Engineering.*) A horizontal ledge on the side of a cutting, an embankment, or parapet. A *berme*; a *banquette*.

2. A support for tools and work in various mechanical operations, as carpentry, metal and leather working, etc.

The bench is of a thick plank, or, better still, a number of pieces of scantling glued and bolted together, — a combination which resists warping better than any mere plank, however thick or well braced. At the back part is a shallow trough *l* to hold small tools. *a b* are, respectively, a toothed and a square bench-hook, which slip in vertical mortises so as to assume any required elevation, or be driven down flush with the surface of the bench. *k* is a holdfast, which clamps work to the bench.

Fig. 656.



Carpenter's Bench.

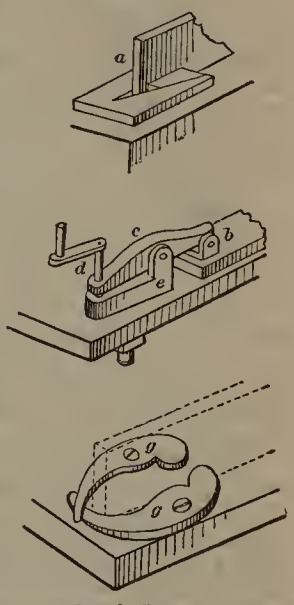
d c are the screws of a bench-vise *e*, by which work is held. The screw *d* has a garter *f*, which enters a notch in the cylindrical neck of the screw, keying it in the jaw, so that the latter follows the inward and outward motions of the screw. A number of stops are placed along the front of the bench, either of which may be raised to hold one end of a piece of work, while the other end is held by the stop *j* on the sliding-piece *h*, which is moved by the end-screw *g*.

When a board is placed edgeways in the vise *e*, its bottom edge may rest on a pin *m*, which is placed in either one of the vertical series of holes in the post.

Bench-clamp. A jaw-tool attached to a work-bench for holding an article to be operated on in place.

The bench-clamp is shown on a painting in Herculaneum, where it is used to dog a timber to a bench while it is being sawed by a frame-saw.

Fig. 657.



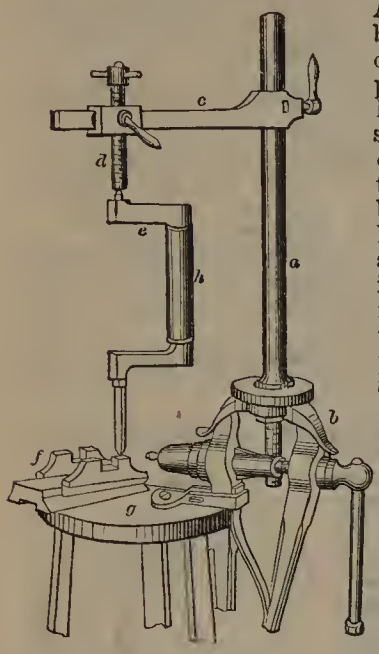
Bench-Clamps.

In one form, *a*, the board, when set on edge, is clamped by two wedges between the angular cheeks.

In another, the clamp *b* has an arm *c*, which is pressed downward upon the work to be held by means of the screw *d*, whose end rests on the base-piece of the clamp *e*.

Another clamp is formed of two pivoted dogs *g g*, between whose heads the board slips. The board is shown in dotted lines, and pressure against the tails of the dogs clamps their heads against the sides of the board.

Fig. 658.



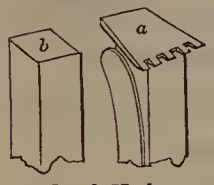
Bench-Drill.

Bench-drill. A drill adapted to be used on a machinist's or carpenter's bench. In the example shown, a post *a* is erected between the jaws of the bench-vise *b*, and has a vertically adjustable arm *c*, in which is the feed-screw *d*, which forms the pintle or *back-center* of the brace *e*. The work *f* is placed on the bench *g*, and the brace is rotated by the hand, which grasps the loose sleeve *h*.

Bench-ham'mer. (*Metal-working.*) A finisher's or blacksmith's hammer. They are of various sizes and shapes for different kinds of work.

Bench-hook. A stop or abutment which occupies a vertical mortise in a carpenter's bench, and is adjustable to any required elevation, to stay the wood being planed; or may be driven flush with the surface of the bench when its services are not needed.

Fig. 659.

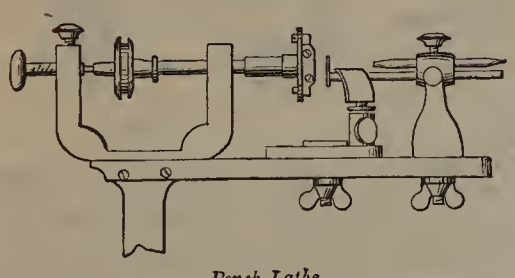


Bench-Hooks.

One of the hooks *a* has a notched plate against which the wood is driven in planing; the other hook *b* is square, so as not to damage nearly finished work.

Bench-lathe. A small lathe such as may be mounted on a post which stands in a

Fig. 660.



Bench-Lathe.

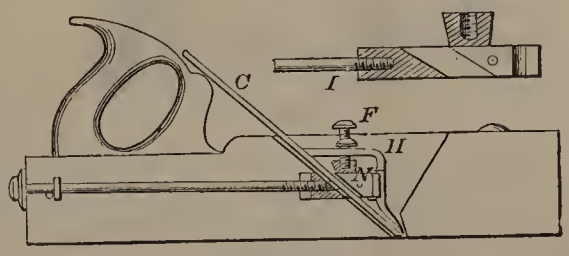
bench. In the illustration, the mandrel carries a face-plate with centering devices, and may be driven by a cord from a treadle or by a bow. The tail-stock and rest are adjustable by thumb-nuts.

Bench-mark. (*Surveying.*) A mark showing the starting-point in leveling along a line; also similar marks affixed at convenient distances to substantial or permanent objects, to show the exact points upon which the leveling-staffs were placed when the various levels were read, thus facilitating reference and correction.

Bench-plane. A joiner's plane for working a flat surface. They are named, in the order of their fineness, *jack*, *long*, *trying panel*, *smooth*, *jointer* planes (which see).

It consists of a stock traversed by a slot in which is wedged a slanting knife, sharpened at its lower edge, and called the plane-bit. The opening in the *sole* through which the *bit* protrudes is called the throat. The degree of protrusion of the bit determines the rankness of the cut and the consequent thickness of the shaving. The bit is usually held

Fig. 661.



Bench-Plane.

by a wedge driven in from above, but clamping arrangements have been suggested, though they are not in much favor. In the one shown, the cap-piece is held against the bit by means of a screw *I* passing from the heel of the plane to the nut *N* in contact with the cap *H* and bit *C*, and a second screw *F*, which pushes down the nut in the cap-piece.

Bench-reel. A spinning-wheel on the pirn of which the sailmaker winds the yarn.

Bench-screw. (*Carpentry.*) The wooden screw which operates the movable jaw of the joiner's bench-vise. See BENCH.

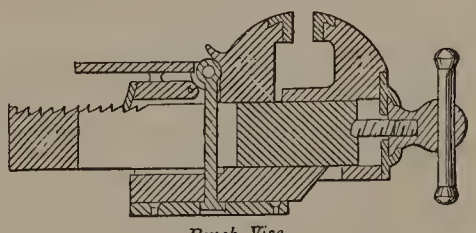
Bench-shears. Hand-shears, the end of whose lower limb is turned at right angles and is received in a socket in the bench.

Bench-strip. (*Carpentry.*) A batten or strip on a carpenter's bench which may be fixed at a given distance from the edge to assist in steadying the work. It may form a fence or a guide.

Bench-vise. A vise provided with means for attachment to a wood or metal worker's bench. In the vise of the carpenter's bench the movable wooden jaw is clamped against the stationary jaw of the bench by means of a wooden screw rotated by a lever occupying a slot in the head.

In the ordinary metal-worker's vise the jaws are both of iron, and one of them has a spreading claw which is screwed fast to the bench. In parallel

Fig. 662.



Bench-Vise.

vises, however, other means of fastening are adopted. (See VISE.) In the illustration, one jaw slips on the bar as the nut is rotated by the handle; the other jaw is fixed in the required position on the said bar by means of a pawl.

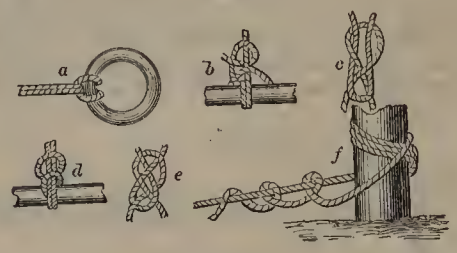
Bend. 1. (*Shipwrighting.*) *a.* One of the strong planks or *wales* on a vessel's sides to which the beams, knees, and futtocks are bolted. See WALE.

b. The cross-section of a building-draft. A *bend* represents the molding edge of a *frame*.

2. (*Mining.*) An indurated argillaceous substance.

3. (*Nautical.*) A knot by which one rope is fastened to another, or to an object such as a ring, spar, or post.

Fig. 663.



Bends.

a, a *loop*-bend. *d*, a *rolling* bend.
b, a *fisherman's* bend. *e*, a *carrick* bend.
c, a *common* bend.
f, a *mooring*-bend, in which the rope is bent to a post or *bollard* on a pier or wharf.

Bend'ing. A process applied to plates to form them into cylindrical shapes, or angular shapes for boilers, angle-iron, etc.

When the material is brought to a corrugated form it is termed CORRUGATING (which see).

The bending of wood for thills, bows, fellies, plow-handles, etc., is usually while steam-hot, and supported in clamps and formers.

Angle-iron for ships' frames is bent to give the proper figure to the molding edge, by means of a *leveling-block* or by a *swage*. The former is adapted to produce sharp curvatures. See LEVELING-BLOCK.

The *swage* consists of a fixed curved bed and a reciprocating block. One side of the bar to be bent or straightened rests against a pair of fixed blocks, with slightly rounded surfaces. Midway between those fixed blocks the opposite side of the bar is pressed against by a block having a reciprocating motion. The position of the fixed blocks and the length of the stroke of the movable block are capable of adjustment, according to the alteration to be produced in the figure of the bars.

Bending of plates for ships' sides is performed by passing them between a pair of bed-rollers and a free roller above, whose bearings are adjustable by means of screws so as to give any required curvature to the plate.

Boiler-plates are bent in the same way.

Bend'ing-strake. (*Shipwrighting.*) Two strakes wrought near the coverings of the deck, worked all fore and aft a little thicker than the rest of the deck, and let down between the beams and ledges so that the upper side is even with the rest.

Bend-leath'er. A superior quality of sole-leather.

Ben-gal'. (*Fabric.*) *a.* A thin, light Bengalee stuff, made of silk and hair, for women's apparel.

b. An imitation of striped muslin. (*Bengal-stripes.*)

Ben-gal'-light. (*Pyrotechnics.*) A kind of fire-work, giving a vivid and sustained blue light, used as a signal; also written *Bengola*.

The composition for Bengal-lights is, 1 part antimony, 2 sulphur, 2 mealed powder, and 8 nitrate of soda. These are finely pulverized and thoroughly incorporated together, and the composition is pressed into earthen bowls or similar shallow vessels. When not used immediately, the mouth should be covered with waxed paper to exclude moisture.

Ben-gal'-stripes. (*Fabric.*) A Bengalee striped cotton cloth.

Bent. One section of the frame of a building, which is put together on the ground or foundation, and then raised by holding the feet of the posts and elevating the upper portion. A bent consists of posts united by the beams which pass transversely across the building. When raised, it is secured by the beams of the side to the other bents.

Bent-gage. (*Wood-working, etc.*) One whose blade forms an angle with the handle. Used by wood-workers and sculptors.

Bent-gouge. (*Wood-working.*) A gouge bent towards the basil, and used for scooping or hollowing out concave surfaces. A *bent-neck gouge*.

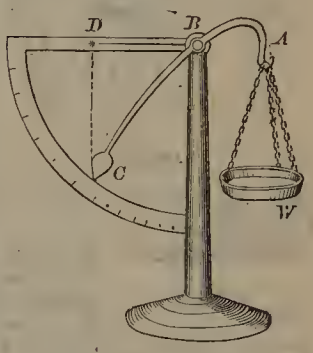
Bent-gra'ver. 1. (*Jewelry.*) A *scorper*.

2. (*Engraving.*) A graver with a blade so bent as to reach a surface whose plane is lower than a marginal rim. Used in chasing and in engraving monograms in sunken tablets.

Bent-le'ver. A lever the two arms of which form an angle at whose apex is the fulcrum; as, a bell-crank lever.

Bent-le'ver Bal'ance. A weighing-scale in which the scale-pan *W* is attached to the short end *A* of a bent-lever, which is pivoted on the summit of a post *B*, and whose weighted end *C* traverses a graduated arc to a distance proportioned to the weight in the pan *W*. As the weight *C* ascends, its leverage becomes greater, and it balances a correspondingly greater weight in the pan *W*. Its leverage in the position shown is indicated by the vertical dotted line dropped from *D*.

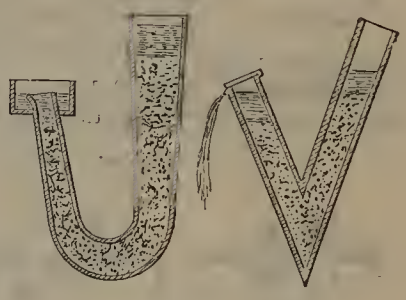
Fig. 664.



Bent-Lever Balance.

Bent-pipe Fil'ter. A tube whose bend forms a containing receptacle for a certain quantity of sand through which water passes, entering at one leg and being discharged at the other.

Fig. 665.



Bent-Pipe Filter.

Bent-rasp. One having a curved blade. Used by gun-stockers and sculptors.

Ben'zole. Discovered by Faraday in oils in 1825, and by C. B. Mansfield in coal-tar, 1849. The latter was fatally burned while experimenting with it in 1855. Aniline is produced from it, and is the source of the celebrated modern dyes, mauve, magenta, etc.

Ber'ga-mot. (*Fabric.*) A coarse tapestry, said to have been first made at Bergamo, Italy. It is composed of flocks of wool, hair, silk, cotton, or hemp.

Ber'lin. (*Vehicle.*) A species of four-wheeled carriage having a sheltered seat behind the body and separate from it. Introduced previous to 1673 by Philip de Chiese, of Piedmont, in the service of William, Elector of Brandenburgh

Berme. 1. (*Fortification.*) A narrow, level space at the foot of the exterior slope of a parapet, to keep the crumbling of the parapet from falling into the ditch. See ABATTIS.

2. (*Engineering.*) A ledge or bench on the side

or at the foot of a bank, parapet, or cutting, to catch earth that may roll down the slope or to strengthen the bank.

In canals, it is a ledge on the opposite side to the tow-path, at the foot of a talus or slope, to keep earth which may roll down the bank from falling into the water.

Slopes in successive benches have a berme at each notch, or, when a change of slope occurs, on reaching a different soil.

Berth. A sleeping-space of limited dimensions on board ship or on a railway-car. It consists of a box or shelf, usually permanent on shipboard, occupying a space against the wall of a state-room or cabin.

In railway-cars berths are usually made at two elevations; the lower one is made up by bridging the space between two adjacent seats, the upper berth by letting down a shelf from above. See SLEEPING-CAR.

Berth and Space. (*Shipwrighting.*) The distance between the molding-edge of one bent or frame of a ship to the molding of another bent or frame. Same as *room and space*.

Bes'se-mer Pro'cess. A metallurgic process which serves as a substitute for puddling with certain descriptions of cast-iron, and for the manufacture of iron or steely-iron for many purposes.

Steel is a compound of iron and carbon, standing in the series between wrought-iron and cast-iron, the former having less carbon, and the latter more, than steel. An old authority gives the contents of carbon in different classes as follows: —

Pure refined iron contains	0.00	per cent.
Soft cast-steel "	0.33	"
Common cast-steel "	1.00	"
Harder cast-steel "	3.33	"
White cast-iron "	4.00	"
Mottled cast-iron "	5.00	"
Black cast-iron "	8.00	"

The old-fashioned way of manufacturing the so-called *blister* steel was to first produce a refined iron, and then cause the bars to re-absorb the necessary quantity of carbon in the cementation furnace, where they were treated, imbedded in charcoal for at least a fortnight. This steel broken up and re-melted in crucibles forms *cast*-steel. The refining of iron in a puddling-furnace to the point where it assumed the character of steel was the next step in the process. See STEEL.

Mr. Bessemer's process is as follows: —

The iron which is to be converted into steel is melted in cupola furnaces, and tapped off into a large ladle standing upon scales, where the weight of the charge may be accurately determined. When everything is ready, the charge, of about twelve thousand pounds, is run into one of the "convertors." This is an egg-shaped iron vessel, about fifteen feet high and nine feet diameter, hung by trunnions upon a ponderous iron framework. To one trunnion is attached a heavy pinion, worked by a rack, driven by a water-engine, which rotates the vessel in a vertical plane. Through the other trunnion, which is hollow, passes an air-pipe, which is continued down the outside of the vessel, and opens into a chamber at the bottom of the "convertor." (See CONVERTOR.) This chamber communicates with the main cavity of the vessel through 120 holes, each three eighths of an inch in diameter. These holes are contained in ten cylindrical fire-bricks, imbedded in refractory materials, and the whole bottom — chamber and all — is removable at pleasure. The main cavity is lined a foot thick with a mixture of crushed quartz, sand, and clay, and opens at the top obliquely upward through a "nose" pointing towards the chimney. It is evident that the blast must pass through a trunnion, because the vessel could not be rotated if received in any other manner. Prior to receiving the charge, the lining is heated nearly to whiteness, and the vessel is inclined to a horizontal position, or beyond, in order to keep the air-holes above the fluid iron while charging. The blast is then turned on, the vessel righted, and the pressure of the blast keeps the metal from pouring through the air-holes. Immediately the reactions commence.

The cast-iron used in the convertor contains about two per cent of silicon, which has a powerful affinity for oxygen, and the combustion of which generates enormous heat. When the carbon oxidizes, which it does in the later stage of the conversion, a long body of flame issues from the convertor of a dazzling whiteness. It is so brilliant that the eye can scarcely endure it, and with the heavy roar of the blast, the rumbling from the volcanic turmoil within, and the showers of sparks blown out of the vessel in thousands of scintillating pellets, forms a scene which must be witnessed in order to be appreciated.

The completion of the blow and the exhaustion of the impurities is denoted almost instantaneously by a change in the whiteness of the flame to a hollow, lurid, translucent glare, accompanied with smoke. The change occupies scarcely three seconds, and great care must be taken to turn down the vessel the moment the conversion is complete. The product contained in the convertor is nearly pure iron, in a state of perfect fluidity. A small quantity of oxide of iron is mechanically mingled with it, which must be removed, and for this purpose five or six per cent of spiegeleisen is run into the vessel. The manganese of this metal at once decomposes the oxide of iron, takes up its oxygen, freeing the iron, and passes into the slag an oxide of manganese. The carbon of the spiegeleisen is partly oxidized and partly remains in the iron, giving it its steel properties. After waiting a few seconds for this reaction to complete itself, the vessel is rotated farther down, and its contents discharged through the nose into the ladle wielded by a huge hydraulic crane, and then poured through a hole in the bottom of the ladle into iron ingot-molds. The blowing occupies about twenty minutes, and the loss of metal is about thirteen per cent.

The rotation of the convertor, which, together with its charge, weighs over thirty tons, the shifting of the ingot-molds, ladles, and other parts, and the removal of the ingots, are all effected by hydraulic power. The American form of the apparatus is the work of Mr. Holley, and is a total renovation of the English method and a great improvement.

HOLLEY'S convertor has a joint below the trunnions, and the lower portion of the bulb may be taken off, placed on a car, and wheeled away, so that the workmen may be able to get directly at the tuyeres, and can set them quickly and strongly by ramming *ganister* solidly around them, instead of pouring it around them in a semi-fluid state, as in the cases where the bottom of the convertor is reached through the mouth. By having some supplementary bottom-sections to replace at once those in which the tuyeres have become burned out or worn too short, the daily working capacity is about doubled.

The ingots are highly crystalline, and generally contain many cavities, which, however, have not been exposed to the air, and therefore close together perfectly under hammer or in the rolls. The weight of the ingot is about 1,400 pounds, and it will make two railway bars. It cannot usually be hammered until after it has been cooled and reheated. It averages a foot square, is three or three and a half

feet high, and has considerable taper. In order to enter a 23-inch train of rolls, it must be "bloomed" down to about six inches, and for this purpose it is reheated to full orange redness, hammered, and cut in two. It is reheated a second time for rolling, and each "bloom" receives 17 passes, issuing from the last one over 30 feet in length. The ragged ends are sawed off by two saws, placed 28 feet 5 inches apart, and when cool the bar is just 28 feet long, having contracted 5 inches, and weighs usually 67 pounds to the yard, — more or less, of course, according to the pattern.

Best-work. (*Mining.*) A miner's term of the best or richest class of ore.

Bê-ton'. Specifically, the French term for concrete; a concrete, the invention of M. Coignet, composed usually of sand 5, lime 1, hydraulic cement .25. The materials are mixed by a shovel, ground violently in a tempering-mill, water being added sparingly from time to time. The pug-mill has a vertical cylinder and a shaft armed with knives spirally arranged, beneath which is a cycloidal presser which drives the plastic béton out at holes in the bottom of the mill. This is carefully and persistently rammed in molds, a stratum at a time, till the mold is full. The top of each stratum is deeply scratched to bind its successor thereto. The molds are coffers *in situ*, or ordinary molds, according to circumstances. The reduction by ramming is very great, about 1.7 to 1. The weight becomes 140 pounds to the cubic foot. The resistance to crushing is 5,000 pounds to the square inch; ten times that of a common mortar made of the same materials and proportions.

Sewers made on this plan may have the centering removed in eight hours, and in four or five days they may be used. Arches with a pitch of 1 in 10 have proportions, sand 5, lime 1, hydraulic cement, .5. In Paris, arches, floors, foundations, barracks, and churches are made of this material. A dwelling of five stories, in Miromesnil Street, Paris, is constructed of a single mass of béton; a staircase of the same material runs in helicoidal form from the basement to the highest floor, molded in the position where it stands.

In making foundations of blocks of hydraulic concrete, sheet piling is first driven, and forms a wall or curb to maintain the concrete in place until *set*.

This is an old Roman method, and was described by Vitruvius. It has also been used by the French in their works in Algiers. Blocks of 324 cubic feet were floated out and dropped from slings into their places.

English recipe: —

Puzzuolana	12
Quicklime	9
Sand	6
Stone spalls	9
Iron scales	3

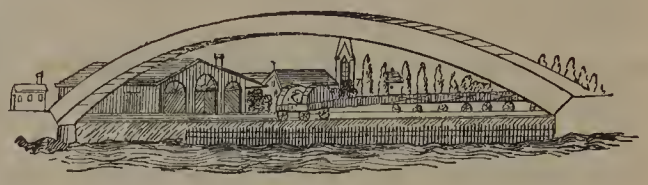
Molded or mixed in a box.

M. Coignet erected a test arch at St. Denis, near Paris, whose dimensions are as follows: —

Span	196 feet.
Rise of arch	19 "
Cross-section at the crown	4 feet by 3.25 "
Cross-section at the springing	6.5 feet by 6.5 "
Specific gravity of the material	2.200
Weight of arch	260 tons.

The arch was constructed in six days, being formed in thin concentric layers. After it had reached what was deemed a sufficient size, it was allowed to remain for five or six weeks, at the end of which time all extraneous supports were removed. This was several years ago, and it yet stands uninjured, and promises to remain an enduring monument of the skill of its constructor. The total amount of depression sustained by the center of the arch after the centering had been removed was barely three eighths of an inch.

Fig. 666.



Béton Bridge.

Bet'ty. (*Slang.*) A short crowbar; a jemmy.

Be-tweens'. A grade of needles between *sharps* and *blunts*.

Bev'el. 1. Any angle except one of 90°.

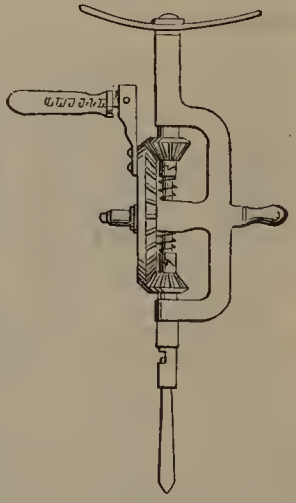
2. An instrument for setting off any angle or bevel from a straight line or surface, much used by artificers of all descriptions for adjusting the abutting surfaces of work to the same inclination. It is composed of two jointed arms, one of which is brought up square against the line or surface from which the angle is to be set off, and the other then adjusted to the desired bevel or inclination. See BEVEL-SQUARE.

3. (*Printing.*) A slug cast nearly type-high and with chamfered edges. Used by stereotypers.

4. The obliquity of the edge of a saw-tooth across the face of the blade.

Bev'el-gear'ing. (*Gear.*) Cogged wheels whose axes form an angle with each other, the faces of the cogs being oblique with their shafts, the sum of the angles of the teeth with their respective shafts being equal to 90°. The illustration shows a breast-drill in which a bevel-wheel drives two bevel-pinions on the stock of the drill; one pinion is for cutting, the other for feed.

Fig. 667.



Bevel-Gearing.

Bev'el-ing. 1. (*Carpentry.*) The sloping of an arris, removing the square edge.

2. (*Shipwrighting.*) *a.* The opening and closing of angle-iron frames in order to meet the plates which form the *skin* of the ship, so that the *faying* surface of the *side-arm* of the angle-iron may exactly correspond to the shape of the plating.

The beveling is performed by smiths while the iron is lying hot upon the leveling-block.

b. The angles which the sides and edges of each piece of the frame make with each other.

A *standing* beveling is made on the outside; an *under* beveling is one on an inner surface of a frame of timber.

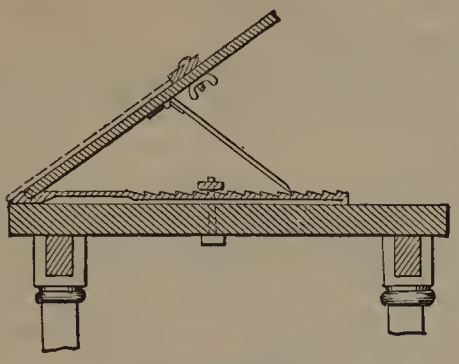
Bev'el-ing-board. (*Shipbuilding.*) A flat piece of wood on which the bevelings of the several pieces of a ship's structure are marked.

Bev'el-ing-edge. (*Shipbuilding.*) One edge of a ship's frame which is in contact with the skin, and

which is worked from the *molding-edge* or that which is represented in the draft.

Bev'el-ing-ma-chine'. (*Bookbinding.*) A machine in which the edge of a board or book-cover is beveled. The table on which the material is laid is hinged to the bed-piece, and may be supported at any desired angle by the pawl-brace and a rack, so as to present the material at any inclination to the knife.

Fig. 668.

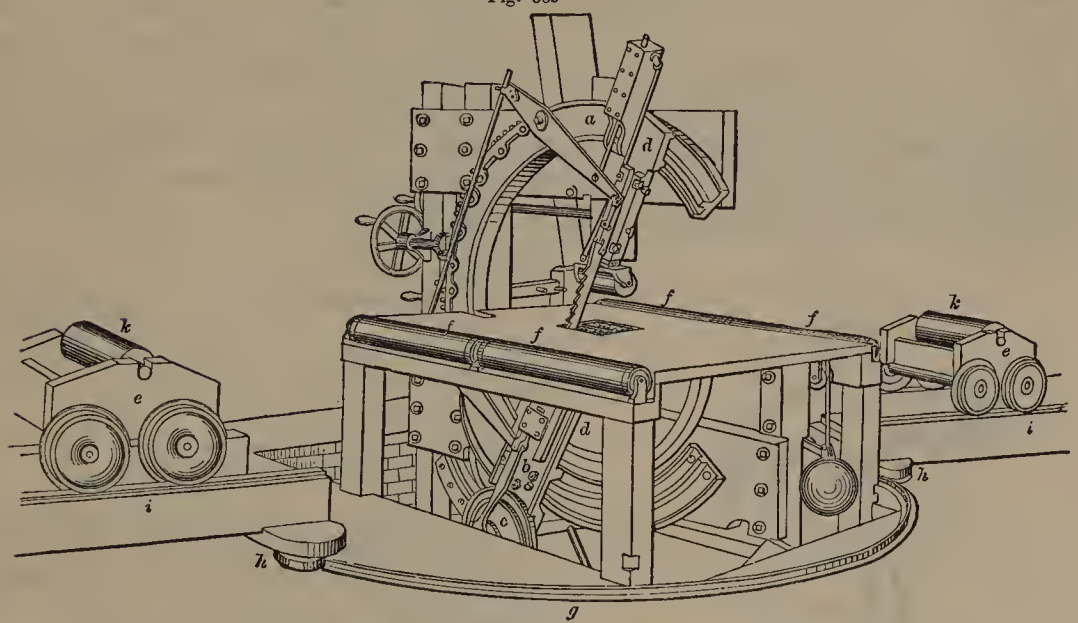


Beveling-Machine.

Bev'el Plumb-rule. (*Engineering.*) A surveyor's instrument for adjusting the slope of embankments.

Bev'el Scroll-saw. A machine for sawing ship-timber to the proper curve and bevel. The saw is mounted on a circular frame *a*, and reciprocated by means of a rod *b* and eccentric *c*. By inclining the saw in its frame any required bevel may be cut, the curve being given by moving the carriage *d d* on its circular track *a*, so as to vary the presentation of the timber. The timbers rest on the rollers *f f* of the table; but if long, are likewise supported by the rollers *k k* of the carriages *e e*, which run towards and from the saw on tracks *i i*. To change the presentation for oblique or circular cut, the carriages *i i* move in concert — if the timber be long enough to bring

Fig. 669

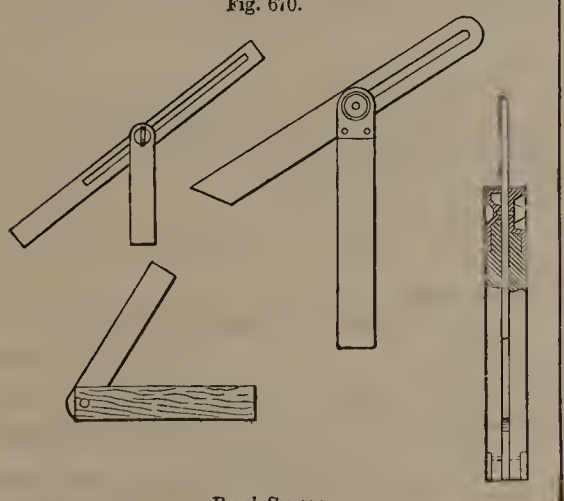


Bevel Scroll-Saw.

them both into action — around the track *g*, against whose flange the guide-rollers *h h* bear.

Bev'el-square. One whose blade is adjustable to any angle in the stock, and retained at any *set* by a clamping-screw; a bevel. The cut shows several forms and positions.

Fig. 670.

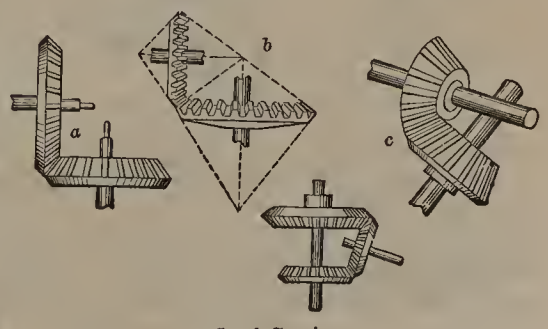


Bevel-Square.

Bev'el-tool. (*Turning.*) A turner's tool for forming grooves and tapers in wood. *Right-hand* or *left-hand* bevels are used, according as the work tapers to the right or left of the workman.

Bev'el-wheel. (*Gear.*) The term is applied to

Fig. 671.



Bevel-Gearing.

a cog-wheel whose working-face is oblique with the axis. Its use is usually in connection with another bevel-wheel on a shaft at right angles to that of the former, but not always so. When the wheels are of the same size and their shafts have a rectangular relation, the working-faces of the wheels are at an angle of 45° with the respective shafts, and the result is *miter* gears *a*. If this relation of the shafts be maintained, but the wheels are varied in size, *b*, the angles of their faces will vary. As before, however, their cogs are cut at right angles to the surface of two cones whose apexes coincide with the point where the axes of the wheels would meet.

When the shafts are arranged obliquely to each other, *c*, a certain obliquity of the cogs of the wheels becomes necessary.

The lower figure in the cut shows a mode of obtaining two different speeds on the same shaft from one driving-wheel.

The term *bevel-wheel* applies in strictness only to a wheel the angle of whose working-face is more or less than 45°, the latter being a *miter-wheel*.

Be-zan. (*Fabric.*) A Bengalee white or striped cotton cloth.

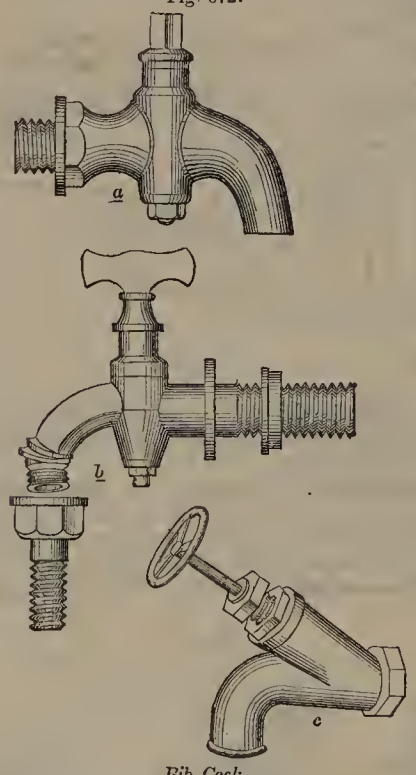
Bez'el. A term applied by watchmakers and jewelers to the groove and projecting flange or lip by which the crystal of a watch or the stone of a jewel is retained in its setting. An *ouch*.

Bib'ble-press. A press for rolling rocket-cases.

Bibbs. (*Nautical.*) Cleats bolted to the hounds of a mast to support the *trestle-trees*.

Bib-cock. A cock or faucet having a *bent down* nozzle; a *bib*.

Fig. 672.



Bib-Cock.

a is a *bib-cock* with a square for the key.

b is a *bib-cock* with a union-joint on the nose for the connection of hose.

c is a *bib-valve*, the closure being by a reciprocating slide instead of a rotary spigot.

Bi'chord Pi-a'no-for'te. (*Music.*) A piano with a grand movement, but possessing but two strings to a note. A *semi-grand* piano-forte.

Bick-i'ron. A small anvil with a tang which stands in a hole of a work-bench. A *beak-iron*.

Bi-cy'cle. (*Vehicle.*) A two-wheeled velocipede. The wheels are in line; the fore-wheel is driven by the feet.

Johnson's old English patent for a *hobby* was a bicycle. See VELOCIPEDE.

Bid'der-y-ware. (*Alloy.*) This is made at Bider, a town about sixty miles from Hyderabad, India. Dr. Heyne states its proportions as —

Copper	8
Lead	4
Tin	1

To 3 ounces of this alloy 16 ounces of zinc are added when the alloy is melted for use. It is colored by dipping into a solution of sal-ammoniac, saltpeter, common salt, and sulphate of copper. This colors it, and the color forms a ground for the silver and gold inlaying. Chisels and gravers are employed, and after the inlaying is complete, the ware is polished and stained.

Another formula gives, zinc 128, copper 16, lead 4, tin 2. See ALLOY.

Bi-det'. A form of sitting-bath used for washing the body, the administration of injections, and treatment of hemorrhoids.

Bid-hook. (*Nautical.*) A small boat-hook.

Bier. 1. A hand-barrow adapted to carry a corpse or coffin, or both. Its purpose is its only distinguishing peculiarity to constitute a difference between it and a *stretcher*, *litter*, or *hand-barrow*.

Fig. 673.

Bier.

The bier represented in the accompanying cut was the ordinary form for supporting the dead in ancient Egypt.

The illustration is from the temple at Karnak.

2. (*Weaving.*) A count of 40 threads in the warp or chain of woolen cloth. The number of warp-threads is counted by *biers*; the threads are termed *ends*. Thus, —

In ordinary broadcloth there are 3,600 threads in the warp; these are set in a *sley* or *reed*, about $3\frac{3}{16}$ yards wide. Such a warp is said to be 90 biers. In England, 5 biers or 200 threads go to the *hundred*. This is one of the absurd overdrafts; as, a hundredweight of 112 pounds; a dozen consisting of 13. In some trades a hundred consists of 120 pieces or pounds.

40 warp-threads of woolen yarn on the beam; 5 biers make 100; that is, 100 pairs of threads, 100 above and the same number below, in the *shed*. Common broadcloth, $1\frac{3}{4}$ yards wide, has 18 double-hundreds, or 3,600 warp-threads. Fine broadcloth may have 6,000 warp-threads.

Bight. (*Nautical.*) The loop of a bent rope.

Bi-la'lo. (*Vessel.*) A two-masted vessel of Manilla.

Bil'an-der. (*Vessel.*) A small two-masted vessel used in Holland, principally on the canals.

Bil'bo. (*Weapon.*) 1. A flexible-bladed cutlass from Bilboa.

"To be compassed, like a good bilbo, in the circumference of a peck, hilt to point, heel to head." — *Falstaff* (in the buck-basket).

2. A form of fetters for prisoners, named from Bilboa, Spain, where they were manufactured in

large quantities, and shipped on the vessels of the Spanish Armada.

A long bar of iron was bolted and locked to the deck; a shackle slipped loosely on the bar, and was secured to the ankle of the prisoner.

"Methought I lay
Worse than the mutines in the bilboes." .
Hamlet.

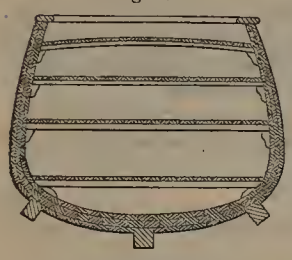
Bilge. 1. (*Shipbuilding.*) The flat portion of a ship's bottom. Here water collects, and is called *bilge-water*. The water is derived from leakage and condensation. The *bilge-water alarm* announces any unusual depth; the *bilge-pumps* remove it.

2. (*Coopering.*) The protuberant middle portion of a cask.

Bilge-board. (*Shipbuilding.*) The board covering the limbers where the bilge-water collects.

Bilge-keel. (*Shipbuilding.*) A longitudinal beam or plate on the bilge of a vessel, for protection from rubbing; or, in the case of iron vessels without true keels, to prevent rolling. Used with vessels having flat bottoms and light draft.

Fig. 674.



Bilge-Keels.

The "Warrior" and some other British iron-clads have bilge-keels.

Bilge-piece. (*Shipwrighting.*) An angle-iron or wooden stringer placed at intervals along the bilge of an iron ship to stay and stiffen the frame.

Bilge-plank. (*Shipwrighting.*) Strengthening planks of the inner or outer skin, at the bilge.

Bilge-pump. (*Nautical.*) *a.* One for pumping the water from the bilge of a vessel. In its old form it had a rod carrying a disk (called a *burr*), to which is nailed a hollow inverted cone of strong leather, the upper edge of which is equal to the diameter of the chamber. When it is thrust down it collapses, allowing the water to pass; when it is raised, the leather cap spreads by the weight of the column, and makes a tight joint with the sides of the chamber.

Formerly also known as a *burr*-pump.

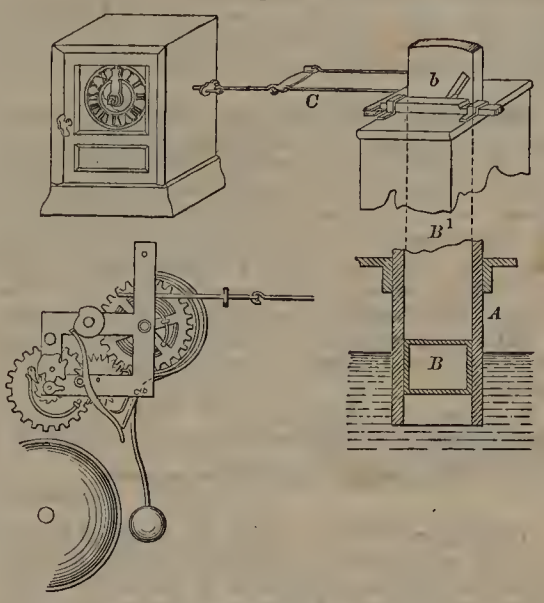
Bilge-pumps are fitted to marine engines as a security to the ship in case of extraordinary leakage, as well as to save the work of the crew in pumping the hold dry. The bilge-pipes should be made of lead, which suffer less corrosion than copper from the acidulous bilge-water of wooden ships.

b. A pump to withdraw water when the ship is laying over so that the water cannot reach the limbers which are reached by the main pumps.

Bilge-wa'ter A-larm'. (*Nautical.*) The ordinary form of these alarms is a well in the hold and a float whose rise is made to free an escapement and sound an ordinary clock-alarm mechanism. In many cases the stem of the float is either graduated to show the hight of the water, or has a rack which operates a spur-wheel and turns an indicator-finger on a dial. These may be read as occasion requires, but are not properly alarms unless with them is associated a device to call attention to the condition of the apparatus.

One form of bilge-water alarm has a vertical rectangular box *A* permanently placed in the water whose rise is to be announced. The float *B* rises with the water, and its stem *B'* has an oblique slot *b*, in which a pin moves and gives motion to a bar *C* connected to clock-work. The latter is placed in any convenient position, and connected to the bar by wire or rods, so as to trip the escapement of the clock-alarm when the float reaches a certain hight. The figures represent, respectively, the indicator-dial, the slotted stem and moving bar, the clock-work, and a vertical section through the float and the lower part of the trunk.

Fig. 675.



Hydraulic Indicator.

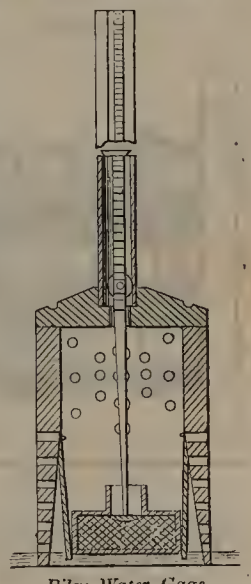
In another form a tube is bent to conform to the transverse sectional shape of the vessel, and is provided with a whistle at each end. At the lowest midship portion the bilge-water is admitted at a gauze-covered opening. When a considerable amount of bilge-water has collected in the pipe, the rolling of the vessel causes the water to expel the air at alternate ends of the pipe, and sounds an alarm.

Fig. 676.

Leak-Alarm.

Bilge-wa'ter Discharge'. (*Nautical.*) A device to secure automatic discharge to the bilge-water. A tube extending from the limber through the outer skin has a rear opening through which a current is induced as the vessel passes through the water.

Fig. 677.



Bilge-Water Gage.

Bilge-wa'ter Gage. (*Nautical.*) A device for

showing the depth of bilge-water in the hold. A graduated stem extending upward from a float in the well where the bilge-water collects. As the float rises, the graduations are read by the officer of the watch.

Bilge'way. (*Shipbuilding.*) The foundation of the *cradle* supporting a ship upon the *sliding-ways* during building and launching. The *sliding-ways* consist of planks 3 or 4 inches wide supported on blocks, and the bilgeways of the cradle slip thereon. The bilgeways are about five sixths the length of the ship, and are about 2 feet 6 inches square. The *cradle* is the carriage which bears the ship into the water and separates from the ship by the act of floating.

Bill. 1. (*Agriculture.*) A hook-shaped cutting-implement, used in heavy pruning, hedging, etc. A *bill-hook.*

2. (*Weapon.*) A hook-shaped blade on a staff, formerly used; the halberd of the infantry soldier.

> "Have a care that your bills be not stolen."
> *Dogberry.*

The bill or bill-hook, under the name of *falx* or *falcula*, was a common weapon among the Romans. A similar implement was used by the Grecks. The figures of Perseus and Saturn are represented thus armed. With this weapon Jupiter wounded Typhon and Hercules slew the Lernæan Hydra.

3. (*Nautical.*) The point on the end of the arm of an anchor beyond the fluke or palm; the *pee.* It is the first part to penetrate the ground, and is made slightly hooking. See ANCHOR.

4. (*Shipwrighting.*) The end of a compass or knee timber.

5. (*Agriculture.*) A mattock.

6. The point of a hook.

Bill-board. (*Shipbuilding.*) An iron-covered board or double planking which projects from the side of the ship and serves to support the inner fluke of the anchor.

Bil'let. (*Saddlery.*) *a.* A strap which enters a buckle.

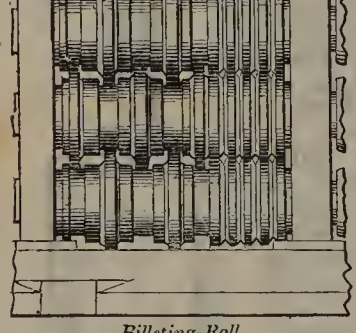
b. A pocket or loop which receives the end of a buckled strap.

Bil'let-head. (*Nautical.*) A piece of wood at the bow of a whale-boat around which the harpoon-line runs; a loggerhead.

Bil'leted Ca'ble. (*Architecture.*) Cabled molding with cinctures.

Bil'let-ing-roll. (*Rolling-Mill.*) A set of rollers for reducing iron to shape, to merchantable bar. In the illustration the passes are shown with flattening and edging grooves.

Fig. 678.



Billeting-Roll.

Bil'let-mold'ing. (*Architecture.*) An ornament used in string courses and the archivolts of windows and doors. It consists of cylindrical blocks with intervals, the blocks lying lengthwise of the cornice. Sometimes in two rows, breaking joint.

Bil'let-note. A folded writing-paper 6 by 8 inches.

Bill-hold'er. A device by means of which bills, memorandums, or other slips of paper, are held and secured, so as to be readily referred to and withdrawn as required.

There are numerous forms: one consists of an upper and a lower band, whose distance apart may be regulated by means of two elastic straps fastened by hasps or fasteners, which allow the straps to be taken up or let out as required.

Another form is a spring clasp; a third is a wire for impaling, either suspended or standing on a foot.

Bill-hook. A thick, heavy knife with a hooked end, useful for chopping off small branches of trees or cutting apart entangled vines, roots, etc.

When a short handle only is attached, this implement is sometimes called a *hand-bill.*

Its lighter forms correspond in their application to the Spanish *machete.*

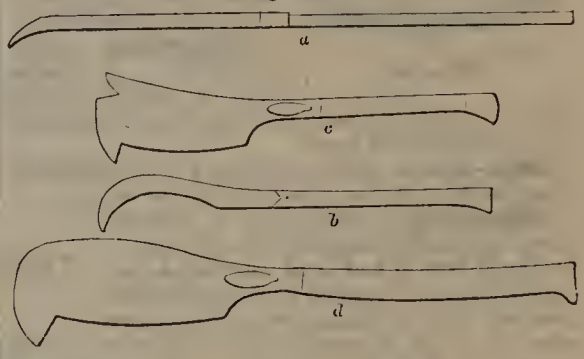
The *bill* is made of a weight and shape proportioned to the work.

The long-handled bill *a* is called a *scimiter;* the handle four feet long.

The short-handled, light-tool *b* is called a *dress-hook,* and is used for trimming off twigs, pruning or cutting back the smaller limbs to preserve the shape of a hedge, shrub, or ornamental tree.

The other two figures, *c d*, represent varieties of bill-hooks for heavier work. The illustrations are

Fig. 679.



Bills.

from English tools; the bill-hook is but little known among us. The axe, hedge-shears, pruning-knife, and occasionally the corn-knife pressed into service as a *machete,* do the work in the United States. One of the principal uses of these tools in England is for hedging. This is on the advance with us; but, as usual, we have contrived a machine, founded on the principle of the *harvester,* which is drawn by horses and trims the hedge to any required shape. See HEDGE PLANTERS AND CLIPPERS.

Bil'liard-cue. The rod with which the billiard-ball is struck. It is sometimes tipped with a vulcanized rubber block.

Bil'liard-mark'er. A counting apparatus for registering the points and games at billiards. There are many varieties.

Bil'liards. A game of skill, played on a smooth, level table of peculiar construction, with hard, elastic balls propelled by a tapering stick called the cue. It was invented either in France or Italy, probably during the sixteenth century. The invention is generally ascribed to Henrique Devigne, an artist in the reign of Charles IX., 1571. The game is spoken of by Shakespeare.

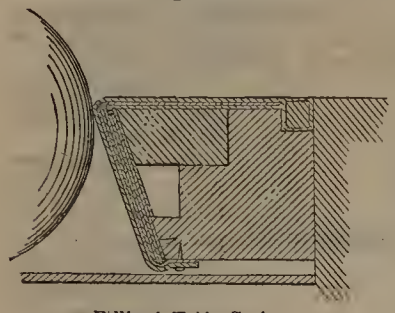
In 1578, during the reign of William, Prince of Orange, permission was given to some residents of Amsterdam to keep billiard-tables.

"Up all of us and to billiards." — PEPYS, 1665.

"After dinner to billiards, where I won an angel." — *Ibid.*

Billiard-tables of the best quality have marble tops covered with cloth. The general appearance is well known. The full-size table is 6 feet by 12, having six pockets, one at each corner and two opposite each other at the midlength of the table. The cushions are the ledges running around the table, which prevent the balls from being projected over its edges; they are lined with resilient material, to cause the balls to rebound, and various materials and devices have been contrived for this purpose, many of which have been the subjects of patents. The cue was introduced about 1670.

Fig. 680.



Billiard-Table Cushion.

Carom tables, destitute of pockets, have come into great favor. The different modes of constructing the cushions have formed the subjects of many patents.

A Kansas billiard-table is thus described: "First, in the middle of the floor was an enormously large box, on which was laid about a wagon-load of sandstone, covered with about eight yards of blue jean. The pockets were made of old boot-legs; for cues they had old hoe-handles; mock-oranges served for balls; and to count this lovely game they used dried apples strung on a clothes-line."

Bil'lon. (*Alloy.*) A German coin-alloy of copper and silver, the former predominating.

Bil'ly. 1. (*Wool-Manufacture.*) A slubbing-machine in which the partially compacted slivers of wool, in the condition of *cardings* or *rolls*, are joined end to end and receive a slight twist, — the preliminary operation in wool-spinning. See SLUBBING-MACHINE.

2. A policeman's mace or club.

Bil'ly-gate. (*Wool-Manufacture.*) The moving carriage in a *slubbing-machine.*

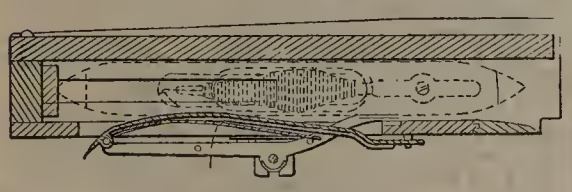
Bi'na-ry-en'gine. Usually an engine having one cylinder whose piston is impelled by steam, which, having done its work there, is exhausted into another part of the apparatus, where it is allowed to communicate its unutilized heat to some liquid volatile at a lower temperature; the vapor of this second liquid, by its expansion in a second cylinder, yields additional useful force. Ether, chloroform, and bisulphide of carbon, have all been tried.

Bind'er. 1. (*Carpentry.*) A *tie-beam.* A binding-joist supporting transversely the bridging-joists above and the ceiling-joists below, to shorten the bearings. See JOIST; FLOOR.

2. (*Shipbuilding.*) A principal part of a ship's frame, such as keel, transom, beam, knee, etc.

3. (*Sewing-machine.*) A device for folding a binding about the edge of a fabric and sewing it thereto. See "Sewing-machine Attachments," a complete digest to 1872, by George W. Gregory, Washington, D. C.

Fig 681.



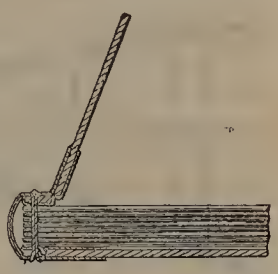
Shuttle-Binder

4. (*Agriculture.*) *a.* An attachment to a reaping-machine which binds the gavels into sheaves.

b. A wisp of straw, a cord, wire, or other band for binding a sheaf of grain.

5. (*Weaving.*) A lever applied in a shuttle-box to arrest the shuttle and prevent its rebounding.

Fig. 682.

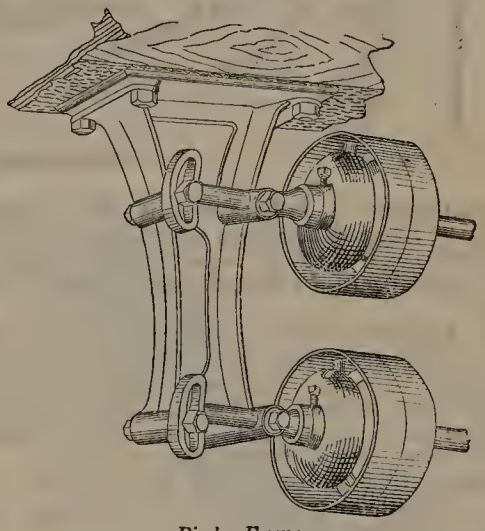


Music-Binder.

6. (*Bookbinding.*) A cover for music, magazines, or papers, forming a temporary binder to keep them in order for convenient reference.

Bind'er-frame. A hanger with adjustable bearings by which the angular position of the shafting may be regulated to suit the plane of motion of the belting.

Fig. 683.



Binder-Frame.

Bind'er's Board. (*Bookbinding.*) A thick sheet of hard, smooth, calendered pasteboard, between which printed sheets are pressed to give them a smooth surface. Also the stiff pasteboards which form the basis of the sides of book covers.

Bind'ing. (*Bookbinding.*) The putting of a cover on a book. In the trade, *binding* is putting on the sides; following the operations of *folding*, *gathering*, *sewing*, *rounding*, and *edge-cutting*, and preceding the *covering*, *tooling*, *lettering*, and *edge-gilding.*

Various kinds of binding are known as —

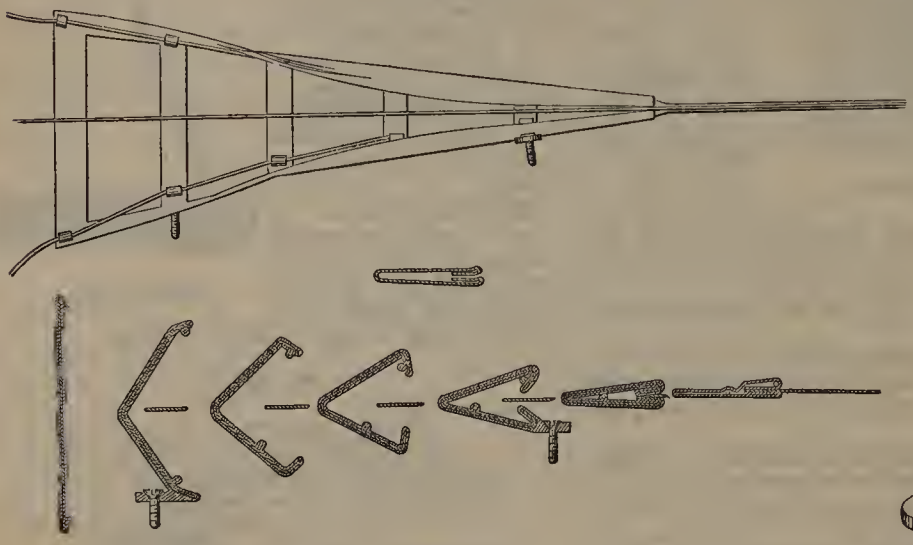
Antique,	India-rubber,
Beveled,	Levant,
Boards,	Morocco,
Buff,	Muslin,
Calf,	Roan,
Cloth,	Russia,
Crushed,	Sheep,
Full,	Vellum,
Half.	Velvet, etc.

Bind'ing-cloth. (*Fabric.*) Dyed and stamped muslin for covering books. The dyed cloth is passed between engraved rollers, or is worked after being cut into patterns of the required size. The engraved

cylinders of hard steel confer the impress characteristic of the back and sides along with embossed designs over the surface in sharp relief. It is a cheap and good substitute for leather, which it has nearly superseded for general use.

Bind'ing-guide. (*Sewing-Machine.*) The device is adapted to receive a binding and fold it about the edge of a piece of material to be bound. Are of two

Fig. 684.



Binding-Guide.

general classes: 1. A flattened tube folded gradually on itself longitudinally from near its receiving to its delivering end, but with a space left for the edge of the material. (See patent to SWEET, December 20, 1853.)

2. Adjustable hooks projecting through the face of a guide and facing each other; the binding is directed by the guide and hooks, the material to be bound rests between the hooks, and the latter are adjustable, to lap the binding more or less on either side. (See patent to PRICE, June 19, 1860.)

Some binders turn in or hem the edges of a bias strip of cloth as it is applied for a binding. (See patent to DOUGLAS, October 5, 1858.)

Bind'ing-joist. (*Carpentry.*) A joist whose ends rest upon the wall-plates, and which support the *bridging* or *floor joists* above and the ceiling joists below. A *binder*. See JOIST; FLOOR.

The binding-joist is employed to carry common joists when the area of the floor or ceiling is so large that it is thrown into bays. With large floors the *binding-joists* are supported by *girders*. See GIRDER.

Binding-joists should have the following dimensions: —

Length of Bearing. Feet.	Depth. Inches.	Width. Inches.
6	6	4
8	7	4½
10	8	5
12	9	5½
14	10	6
16	11	6½
18	12	7
20	13	7½

Bind'ing-plate. One of the side-plates of a puddling or boiling furnace, which are tied together by bolts across the furnace, and by flanges, and serve to bind the parts of the furnace together and prevent the spreading of the arched roofs of the furnace and iron chamber. See PUDDLING-FURNACE.

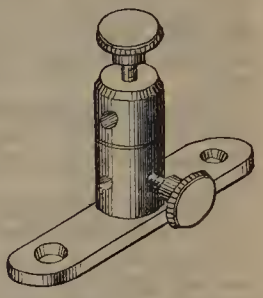
Bind'ing-raft'er. (*Carpentry.*) A longitudinal timber in a roof, supporting the rafters at a point between the comb and eave. See PURLIN.

Bind'ings. 1. (*Shipbuilding.*) The timbers of a ship which hold the *frames* together. Such are the *beams*, *knees*, *clamps*, *water-ways*, etc.

2. (*Nautical.*) The iron wrought around the *dead-eyes*.

Bind'ing-screw. A set-screw which binds or clamps two parts together. The term is applied especially, in instruments of graduation and measurement, to a screw which clamps a part in a given position of adjustment. A screw by which the wire of a galvanic battery is held in close contact with other metallic portions in the circuit.

Fig. 685.



Binding-Screw.

Bind'ing-screw Clamp. (*Galvanism.*) A device used with voltaic batteries; the lower portion is a clamp for the zinc or copper element, which is suspended in the bath; the upper has a hole for the conductor-wire, and a screw which comes forcibly down upon it to ensure contact.

Bind'ing-strakes. (*Shipbuilding.*) Thick strakes, planking, or wales, at points where they may be bolted to knees, shelf-pieces, etc.

Bind'ing-wire. The wrapping-wire for attaching pieces which are to be soldered together, or to hold in intimate contact the parts concerned in a voltaic circuit.

Bind-rail. (*Hydraulic Engineering.*) A piece to which the heads of piles are secured by mortising or otherwise, serving to tie several of them together and as a foundation for the flooring-joists or stringers. A *cap*.

Bing. (*Mining.*) A place for receiving ore ready for smelting. The *bing-hole* is the opening through which it is thrown.

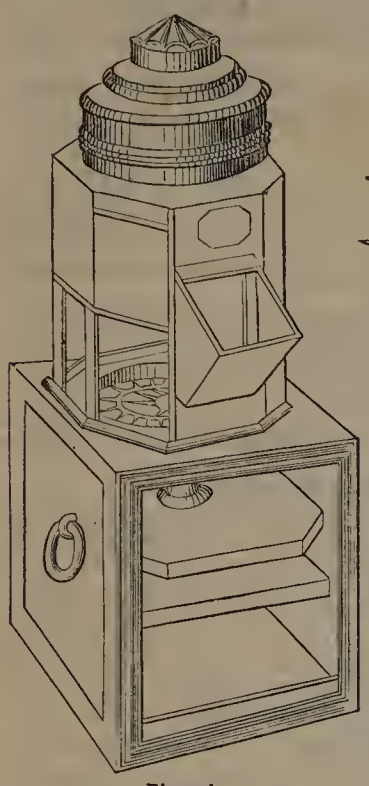
Bink. (*Cotton-Manufacture.*) A stack of cotton in a *bin* or on the floor, consisting of successive layers of cotton from different bales laid in alternating strata, in order to blend them. A *bunker*.

The supply of cotton for the machinery is taken by raking down the take so as to mix the cotton of the successive layers at each *take*.

Bin'na-cle. (Fr. *habittacle*). (*Nautical.*) A case or box for containing the compass of a ship and a light by which it is illuminated at night.

It is placed immediately in front of the wheel or steering-apparatus, and secured to the deck, usually, by metal stays. The after portion has glass windows, so that the compass is at all times visible to the helmsman, who stands at the wheel.

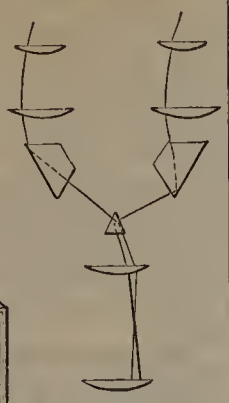
Fig. 686.



Binnacle.

Bin'o-cle. (*Optics.*) A BINOCULAR TELESCOPE (which see).

Fig. 687.



Eye-Piece for Optical Instruments.

Bi-noc'u-lar Eye-piece. (*Optics.*) One in which the eye-piece is so constructed and applied to the object-glass as to divide the optical pencil transmitted to the latter, and form, as to each part of the divided pencil, a real or virtual image of the object beyond the place of division.

Bi-noc'u-lar Glass. (*Optics.*) An eye-glass or telescope to which both eyes may be applied.

Alhazen, the Saracen, who flourished in Egypt and in Spain A. D. 1100, "was the first to correct the Greek misconception as to the nature of vision, showing that the rays of light come from the external object to the eye, and do not issue from the eye and impinge on external things, as up to his time had been supposed. His explanation does not depend upon mere hypothesis or supposition, but is plainly based upon anatomical investigation as well as on geometrical discussion. He determines that the retina is the seat of vision, and that impressions made by light upon it are conveyed along the optic-nerve to the brain. With felicity he explains that we see single when we use both eyes, because of the formation of the visual images on symmetrical portions of the two retinas." — DRAPER.

The camera-obscura of Leonardo da Vinci, b. 1452, was an imitation of the mechanical structure of the eye.

Samuel Pepys, in "His Diary," records a conversation with Dr. Scarborough on board the "Charles," formerly the "Nazeby," on the voyage of Charles II. from the Hague to Dover, May 24, 1660. Dr. Scarborough remarked that custom taught children to direct the axes of the two eyes convergingly upon an object, and presumed that the visual image of but one eye was appreciated at a time. Dr. Scarborough does not seem to have deduced from this that the images differed, and thus imparted the sensation of rotundity or saliency to the object, nor the other fact that the angle of convergence of the axes gave the impression of distance. He came very near to these great deductions.

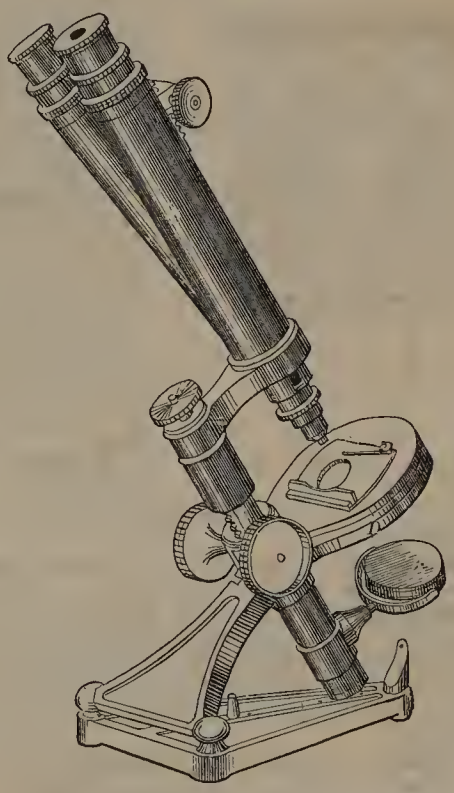
A good illustration of the principle of binocular vision is furnished by the stereoscope, invented by Professor Wheatstone, and forming one result of his discoveries. When we are looking at a raised object with one eye, the result is just the same as if we looked at a flat surface, so far as the colors, shades, etc., are skillfully imitated; but when we look with both eyes, the image in the right eye is not exactly like that in the left, because we view it from a different point of sight. It is true, that this difference depends only on the small distance between the eyes, but this suffices to produce different ocular images. Wheatstone has shown that our appreciation of raised objects depends mainly on this circumstance; and his *stereoscope*, or *binocular glass*, is an ingenious contrivance for making two plain pictures seem to coalesce into one rilievo, or raised object.

Bi-noc'u-lar Mi'cro-scope. (*Optics.*) The invention of the binocular microscope followed that of the stereoscope by Professor Wheatstone, which led to a general appreciation of the value of binocular vision.

Professor Riddel, of New Orleans, and after him Wenham, of London, made attempts to adapt the principle to microscopes. Professor Nachet, of Paris, devised a construction in which the pencil of rays issuing from the objective is divided by an equilateral triangular prism, and, issuing from the right and left sides respectively, the divided pencils are received by similar prisms, which give them a direction parallel to their original course; the interval of separation being determined by the distance between the central and lateral prisms.

Wenham's binocular microscope has but a single prism, which reflects one half of the rays passing

Fig. 689.



Wenham's Binocular Microscope.

through the object-glass into the additional tube of the binocular body.

This instrument can be used as a monocular or binocular. In the former case the prism-box is drawn back so as to allow the whole of the rays from the object-glass to pass into the straight body.

Bi-noc'u-lar Tel'e-scope. (*Optics.*) A pair of telescopes mounted in a stand, and having a parallel adjustment for the width between the eyes. The tubes have a coincident horizontal and vertical adjustment for altitude and azimuth.

Galileo invented the binocular telescope with which he experimented in the harbor of Leghorn on a vessel in rough weather in the year 1617, with a view to the more convenient observation of Jupiter's satellites on board ship. The invention has usually been attributed to the Capuchin monk Schyrleus de Rheita, who had much experience in optical matters, and was seeking to find the means of constructing telescopes which would magnify four thousand times.

Bi'not. (*Agriculture.*) A kind of double-mold board-plow. (English.)

Bird-bolt. A thick, pointless arrow to kill birds without piercing them.

Bird-cage. A box or case of wire, small sticks, wicker, or other suitable material, forming open-work, for confining birds. Pepys states that he bought two fine cages for his "canary-birds. (*Diary*, January 25, 1661.) See CAGE.

Bird-call. A short metallic cylinder, with a circular perforated plate at each end; used to make a trilling noise, as a decoy for birds.

Fig. 639.

Bird-House.

Bird-house. A box for birds, usually set on a pole planted in the ground to prevent access of cats and other vermin. May be made an architectural feature, but is usually a modest affair, put up for the pleasure of seeing the birds and the satisfaction of affording them comfort and protection.

Bird'ing-piece. A fire-arm for killing birds. A shot-gun or FOWLING-PIECE (which see).

Bird-or'gan. A small barrel-organ, used in teaching birds, especially the bullfinch, to sing.

Bird's-mouth. (*Carpentry.*) The notch at the foot of a rafter where it rests upon and against the plate.

Bird's-nest. (*Nautical.*) A lookout-station at a mast-head for a seaman who watches for whales.

Bird-trap. A two-winged flap-net sprung by hand, or a box-trap supported on a figure-of-4, with a trigger to be touched by the bird or sprung by a person on watch. The netting of birds by the former method is well pictured in the ancient Egyptian paintings.

Bi'reme. (*Nautical.*) A two-banked galley.

Bir'lin. (*Nautical.*) Bior-linn; a galley of the Hebrides.

Bir'rus. (*Fabric.*) An old-time coarse woolen cloth.

Bis-cay'an Forge. A furnace in which malleable iron is obtained direct from the ore. See CATALAN.

Bis'cuit. 1. (*Bread.*) *a.* A hard cake of unfermented bread, suitable for sea use. Formerly it was baked a second time to expel the moisture more completely, in order that it might keep without molding. A *cracker*.

b. A small baked cake, rendered spongy by carbonic-acid gas resulting from fermentation, or adding soda and an acid. Or, a small baked cake with shortening of lard or butter.

2. Articles of pottery molded and baked in an oven, preparatory to the glazing and burning. In the *biscuit* form, pottery is bibulous, but the glaze sinks into the pores and fuses in the kiln, forming a vitreous coating to the ware.

Biscuit, by its derivation, means, *twice baked*, and is, or was, true of the edible biscuit; but the name as applied to pottery is derived from the similarity which the ware in this stage bears to the edible biscuit. It is a favorite material for statuettes and ornaments, owing to its soft tone and creamy unglaring surface.

Bis'cuit-mak'ing Ma-chine'. Previous to the introduction of machines for kneading the materials, rolling the dough, and cutting out the biscuits, the flour and water were mixed and kneaded by hand, and then placed on a platform where, by means of a hinged lever called a *break-staff*, the process is completed, the person sitting on the break and bouncing up and down, and at the same time traveling in the arc of a circle, leaving the dough in a thin sheet, very compact and comparatively dry. This was removed from the platform, cut into slices, molded by hand, pricked, and baked.

The biscuit-machine of the Navy Victualling Establishment, Portsmouth, England, is thus described in the United Service Journal: —

"The first operation in making the biscuits consists in mixing the meal and water. 13 gallons of water are poured into a trough, and then 280 pounds of meal. The lid is shut down, and an apparatus, consisting of two sets of knives, is made to revolve among the flour and water by machinery. The mixing lasts 2½ minutes, during which the stirrers make 26 revolutions.

"The lumps of dough are then thrown under the *breaking-rollers*, which are cylinders of iron weighing about 1,500 pounds each, and moved by machinery upon the bench whereon the dough is laid. The dough is thus formed into masses about 6 feet long, 3 feet broad, and several inches thick. The mass, being as yet imperfectly kneaded, is cut into sections about 12 × 18 inches of the thickness mentioned, and is again and again mashed out flat by the traversing roller, being doubled upon itself after each rolling.

"The dough, now perfectly kneaded, is carried by machinery to the rollers, where it is made into sheets of the required thickness. The cutting is effected by a plate, consisting of a network of 52 sharp-edged hexagonal frames, each as large as a biscuit. The frame is moved slowly up and down by machinery, and the workman, watching his opportunity, slides under it the sheet of dough, which is about the size of a leaf of a dining-table. The cutting-frame, in its descent, indents the sheet, not cutting it quite through, but leaving sufficient substance to enable the workman at the mouth of the oven to jerk the whole mass of biscuits undivided into the oven. A follower in each of the cutter-frames moves up and down, giving way as the cutters are pressed upon the dough, and, as the cutters rise, ejecting the dough from the frames.

"The establishment has 9 ovens, each 11 × 13 feet, and 17½ inches in hight. They are heated by separate furnaces, so constructed that a blast of hot air and fire sweeps through them, and gives to the inte-

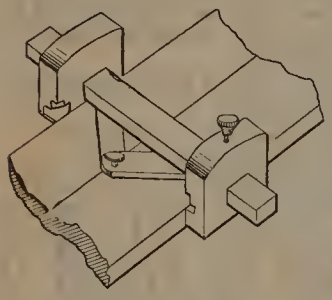
rior the requisite dose of heat in an incredibly short space of time. Fifteen minutes is sufficient for baking, and the biscuit are afterwards placed for three days in a drying-room heated to 80° or 90°, which completes the process.

"The producing capacity of the machinery is 1,790 pounds of biscuit per hour."

Bi-sect'ing Di-vid'ers. Proportional dividers whose legs are permanently pivoted at one third of their length from the shorter end, so that the distance between the two points at that end, when the dividers are opened, is just one half that measured by the longer legs.

Bi-sect'ing Gage. The bar has two cheeks, one adjustable. The ends of the toggle-bar connect to the respective checks, and at the pivot of the toggle is a pencil or scribe-awl which marks a median line between the facing sides of the two cheeks.

Fig. 690.



Bisecting Gage.

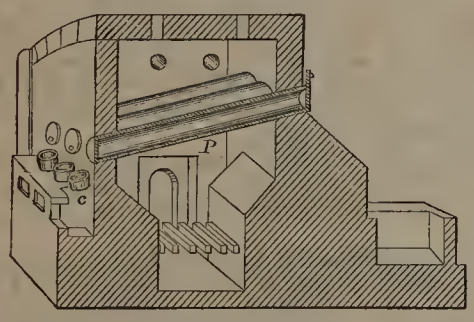
Bis'muth. Equivalent, 212; symbol, *Bi;* specific gravity, 9.823; fusing-point, 497° F. A reddish-white, hard, brittle metal, of radiated crystalline structure.

Its principal use is as an ingredient in alloys, especially those which are designed to fuse at low temperatures, such as the solders and fusible plugs for steam-boilers.

The oxide of bismuth is a cosmetic. See ALLOYS, under the heads of *white metals; solders; fusible alloys.*

Bis'muth Fur'nace. At Seneeberg, in the Saxon Erzegebirge, bismuth is reduced in a furnace similar to that shown in the cut. The raw mineral is in-

Fig. 691.



Bismuth Furnace.

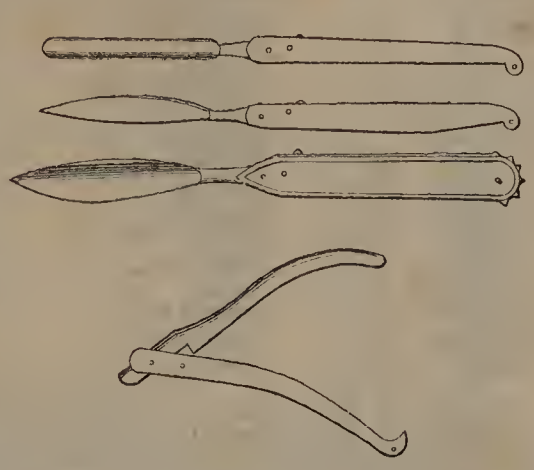
serted into the higher ends of the iron tubes *P*, which are then shut. The lower ends of the tubes are closed by plates having an aperture near the lower edge, through which the melted metal flows, and is received in clay-pots *c*, which are kept hot by a fire beneath. In this state it contains a proportion of sulphur and arsenic, which, however, may be removed by fusing the metal with one tenth its weight of niter.

Bisque. (*Porcelain.*) The baked ceramic articles which are subsequently glazed and burned to form porcelain. See BISCUIT.

Bis'tou-ry. (*Surgical.*) From Pistori, a French town where these knives were early made.

A surgical instrument for making incisions, having a handle and a blade, which may be either fixed or

Fig. 692.



Bistouries.

movable, and variously formed to adapt it to special purposes. Bistouries are known as straight, curved, sharp, probe, etc.

Bi-sul'phide of Car'bon En'gine. A compound engine in which the vapor from bisulphide of carbon is employed in the second cylinder instead of steam as a motive-power. A binary engine.

Two engines are used in the Ellis arrangement. They may be coupled together or used independently. One of these engines is run by steam in the usual way, and its exhaust taken to heat the boiler that drives the other engine; this boiler is filled with a mixed volatile liquid, consisting principally of the bisulphide of carbon, which boils at 110° F., and at the usual temperature of exhaust steam gives a pressure of 65 pounds to the inch. This boiler is heated by passing the exhaust steam through its flues on its way from the cylinder to the atmosphere, and the vapor which is produced in it is used to drive the second engine. The exhaust vapor from this engine is condensed to liquid by cooling, and pumped into the boiler again, and used continuously with very little loss.

Bit. 1. (*Locksmithing.*) The part of a key which enters the lock and acts upon the bolt and tumblers. See KEY.

The *bit* of a key consists of the *web* and the *wards.* The *web* is the portion left after the wards are notched, sawn, or filed out.

In the permutatious locks, each separate piece composing the acting part of the key is termed a bit. These fit upon the stem of the key, from which they are removable, and are interchangeable among themselves, so as to allow the key to be set up with various combinations agreeing with the set of the tumblers.

2. (*Wood-working.*) *a.* A boring tool used by attachment to a *brace,* whereby it is rotated. An *auger* has many points of resemblance to a *bit,* but has a cross-handle whereby it is rotated, whereas a bit is stocked in the socket of a brace, and is rotated thereby.

The following are the varieties of Boring-Bits, and their adjuncts: —

Annular bit.	Broach.
Auger.	Bung-borer.
Auger-bit.	Center-bit.
Awl.	Chamfering-bit.
Bit-holder.	Coal-boring bit.
Boring-bit.	Cone-bit.
Brad-awl.	Countersink-bit.

Dowel-bit.
Drill.
Drill-bit.
Ducks-bill bit.
Expanding-bit.
Faucet-bit.
Felloc auger.
Flute-bit.
French-bit.
German-bit.
Gimlet-bit.
Gouge-bit.
Grooved bit.
Hollow auger.
Shell-auger.
Lip-bit.
Nose-bit.
Opening-bit.
Piereel.
Pod-bit.
Plug-eenter bit.
Pump-bit.
Quill-bit.
Reaming-bit.
Shell-bit.
Spiral bit.
Spiral-rib bit.
Spoon-bit.
Terrier.
Twisted bit.
Vent-bit.
Wimble.

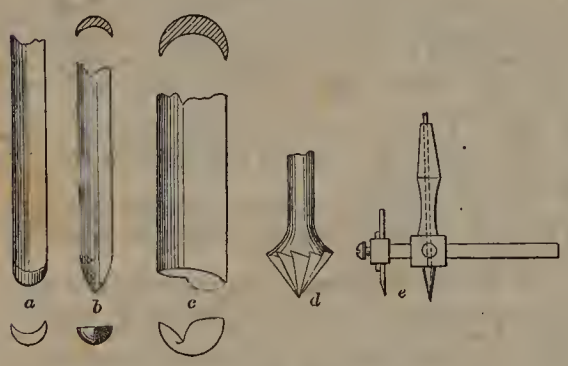
The *gouge-bit* (*a*, Fig. 693), before the invention of the *pod*, *spoon*, and *twisted bits*, resembled the half of a reed split longitudinally, and had a sharp end like a gouge. This was also known as the *quill-bit*, or *shell-bit*.

It was improved by giving a quarter-round end to the semi-cylindrical shank, the sharp end working at the bottom of the hole and removing a spiral chip instead of depending upon the penetration of the sharp end of the tube, as in the gouge-bit. This was a great improvement, and was the *pod-bit*, or *lip-bit*.

The change to the *spoon-bit* (*b*) was merely giving a conoidal end to the tool, which enabled it to enter more accurately at a given spot. This is the *dowel-bit*, being used by coopers on barrel-heads, and by furniture-makers on table-leaves. This is also called the *duck's-bill bit*.

The *nose-bit* or *shell-auger* (*c*), when on a large scale, has the first example of a *table* or *routing* cutter, which is afterwards so prominent a feature in the

Fig. 693.



Boring-Bits.

screw-augers. It has a long barrel, and the large sizes are used by the pump-makers, and called *pump-bits*.

One form of *countersink-bit* has a cutting enlargement on the shank, which, according to its shape, may make a suitable depression for the chamfered head of a screw, its usual purpose, or may serve to sink a bolt-head or nut out of sight in the material. See CHAMFER.

In another form, attached to the shaft of a boring-bit is a countersink, or cutting lip, that will enlarge the hole bored by the bit, it being adjustable on the bit, and having a gage to determine the depth of hole or countersink.

The countersink has two faces, either of which may be presented to the work. One has a tooth and router, which makes a square-bottomed countersink; and the other has a chamfering lip, which makes a conical countersink.

The *chamfering-bit* (*d*), for opening holes so as to admit the conical heads of the ordinary wood-screw, consists of a conical reamer with teeth. It may be employed on wood, metal, or other material which is to receive the head of the wood-screw.

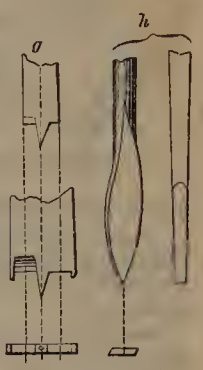
The gage is adjustable on the countersinker, and the latter on the stem of the bit, so the hole may be made of a regulated depth, and the countersink also.

Other gages adaptable to the use of bits are shown under the head of AUGER-GAGE (which see).

The *expanding center-bit* (*e*) consists of a shank and center-point, and a lancet, or chisel-shaped cutter, whose distance from the center is regulated by slipping the bar, like that of a beam-compass, in the socket of the head, a set screw maintaining it at its adjustment. This serves for cutting out disks, or for cutting circles for inlaying.

For cutting hard wood, such as the finger and key holes of flutes, bits are employed with a square point and two diametrical cutting-lips (*g*, Fig. 694); the smaller one approaches very closely the character of a drill, into which, indeed, many of the bits sensibly glide, especially those adapted for working in hard woods, and other materials harder than wood, such as bone and metal.

Fig. 694.



Boring-Bits.

The *French bit* (*h*), for hard wood, is a drill, and as such is used in a lathe-head. The center-point and two sides merge into an easy curve, which is sharpened all the way round and a little beyond the largest part.

The German *pod-bit* (*k*, Fig. 695) has a long elliptical pod and a screw-point. It makes a taper to the end of the hole unless it is driven clear through.

The *center-bit* consists of three parts: a center point or pin, filed triangularly, which serves as a guide for position; a thin cutting-point or nicker that cuts through the fibers and circumscribes the hole; and a broad chisel-edge or router, placed obliquely, and tearing up the wood within the circle marked out by the point.

Center-bits are also made with plug centers, so as to follow in a hole previously made, the *circular cutter* and *router* enlarging the hole. See AUGER.

Another form of the center-bit is that of the wine-cooper, which consists of a conical plug armed with a bit at its end. The hole having been made, the plug instantly drops into the hole and prevents the loss of liquor. See AUGER.

An annular bit, consisting of a center-point without the *router*, but having one or more cutting teeth, is used to cut out disks of metal, wood, horn, bone, shell, or paper for buttons. It is then called a *button-tool*. (See *c*, Fig. 693.) See AUGER, ANNULAR, where several are represented, which only differ in size from the button-tool. This tool also approaches, in principle and action, the TREPHINE and CROWN SAWS (which see).

Twisted drills, differing in some details, are in much favor among American mechanics, but for some reason are not so popular in Europe. They are an American invention, and the subject having been treated once under AUGERS (which see), it will not be well to duplicate the remarks, or perhaps necessary to add to them here.

There are four modes of forming the twist, though they are not equally popular or common : —

A ribbon coiled.

A flat plate twisted.

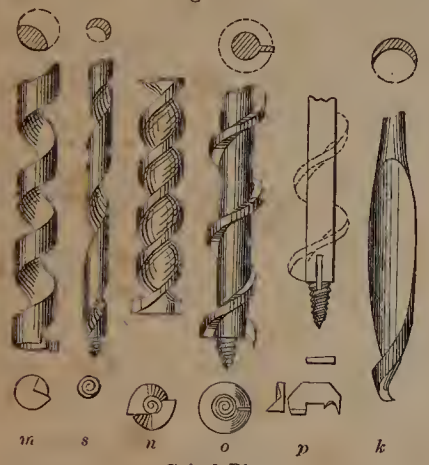
A spiral rib on a straight, central stem.

A spirally grooved cylinder.

The spiral ribbon *m* is a bar having a half-round section. This is twisted so as to throw the flat side to the exterior to form the outside of the cylinder ; the inside is not filled up by the metal, but makes a hollow spiral, and the bottom end has a single cutting-lip.

The twisted flat bar *n* assumes the form of a double-threaded screw, no central vacancy existing in the twist. The end terminates in a worm which *leads* the auger into its work, as in the gimlet, and each of the two lips has a cutting tooth and a routing cutter.

Fig. 695.



Spiral-Bits.

The *spiral-rib* bit *o* is known, especially in England, as the American bit, and has a cylindrical shaft, around which is twisted and brazed a single fin or rib ; or the bit may be swaged between dies, or twisted from a central stem with a single straight rib.

Behind the worm, as in example *p*, may be a small diametric mortise for the reception of a detached cutter which has the nicking-point and cutting-lip of the ordinary center-bit. The cutter is kept in its central position by a square notch which embraces the central shaft of the bit, against which it is forced by a wedge. Cutters of varying sizes may be used.

The *grooved* bit *s* has a cylindrical stem and spiral groove. The groove-shanked gimlet is an example of it.

The Cook and the Kasson bits, in which the cutting-lips are formed by sharpening the curved edges of the worm, are referred to under AUGER (which see). They cut admirably.

The *reaming* bit is a broach of hardened steel, generally four-sided, and used to enlarge holes in metal.

Expanding-bits are useful in two ways : —

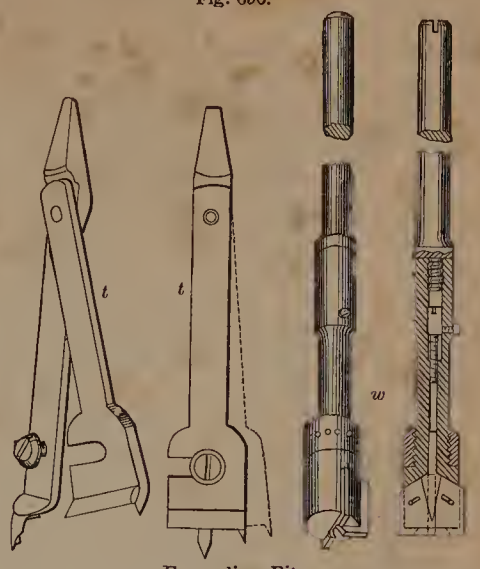
To render a single bit applicable for boring holes of varying sizes.

To enlarge the size of a hole beneath the surface, giving it an undercut or dovetail character.

One form of *expanding-bit*, *t*, has a central portion which has the point, and a hinged portion which carries the scribe and the router. The movable portion is set by a screw, so as to regulate the radius of the hole.

Another form, *w*, has three radial cutters, which are expanded by means of a taper wedge and an axial screw. The latter is operated by a screw-driver,

Fig. 696.



Expanding-Bits.

whose end is introduced into the socket, the threaded end of which is the means of securing it to the brace, chuck, or mandrel.

b. The cutting-iron of a plane. See PLANE-BIT.

c. The cutting-iron inserted in the revolving head of a planing, molding, tonguing, and grooving, or similar machine.

d. The cutting-blade of an axe, hatchet, or similar tool, as distinguished from the pole, which forms a hammer in some tools.

3. (*Harness.*) The iron part of a bridle which is inserted in the mouth of a horse, and having rings by which the *cheek-straps* and reins are attached. See BRIDLE-BIT.

4. (*Jaw-Tools.*) The jaw of a tongs, pinchers, or other similar grasping-tool, e. g. *flat-bit* tongs.

5. (*Tinman's Tools.*) The copper piece of a soldering-tool rivcted to an iron shank. A *copper-bit.*

6. (*Metal-Working.*) A boring-tool for metal, many of which are called *bits ;* as, *half-round bit, rose-bit, cylinder-bit.* See DRILL.

7. The metallic connecting joint for the ribs and stretchers of umbrellas.

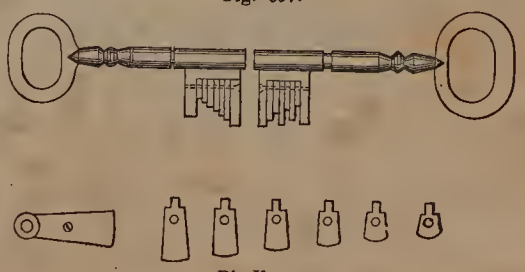
A ∩-shaped piece of metal swaged into shape and clamped or soldered to the rib, which is secured to it by a wire pin passing through an eye in the stretcher and holes in each of its legs. The cross-formed blank is bent up to embrace the back of the rib and closed on to it ; the legs are pierced with holes for the joining-pin ; *Middle-bit ; Get.*

Bite. (*Printing.*) An imperfect portion of an impression, owing to the frisket overlapping a portion of the form and keeping the ink from so much of the paper.

Bite-in. (*Engraving.*) The process of corroding an etched plate. See ETCHING.

Bit-key. A key adapted for the permutation

Fig. 697.

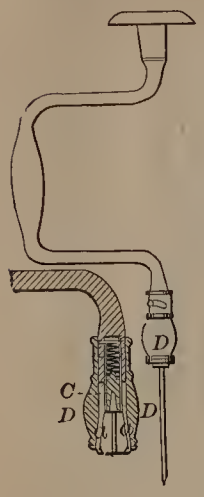


Bit-Key.

lock, the *steps* being formed by movable bits, as in the Hobbs lock.

Bit-stock. The handle by which a bit is held and rotated. It has a flat button upon which the pressure is exerted, and is curved about midway into a D-shape, to afford convenient grasp to the hand. Also called a *brace*. The special devices usually relate to means for firmly holding and readily releasing the bit. In Fig. 698, the end of the shank of the bit abuts against a sliding center-piece *C* backed by a spring. The shoulder of the tool is embraced by the jaws *a a* on the end of the bit-stock; these are closed or opened by a sleeve *D*, which has an inclined slot traversed by a pin, which prescribes the longitudinal motions of the sleeve.

Fig. 698.



Bit-Stock.

Bit-pinch'ers. (*Locksmithing.*) Pinchers having curved or recessed jaws.

Bitt. (*Nautical.*) Primarily, a post secured to several decks, and serving to fasten the cable as the ship rides at anchor. *Riding-bitt; warping-bitt.*

Other *bitts* are used for certain purposes; as —

a. The *pawl-bitts*, to which the pawls of the windlass are secured.

b. The *carrick* or *windlass bitts*, in which the barrel of the windlass is journaled.

c. Winch-bitts, similar in purpose to *b*.

The heel of the bowsprit is stepped between *bowsprit-bitts*, and is prevented from canting up by a cross-piece bolted to the bitts.

d. Belaying-bitts are smaller than *riding-bitts*, and consist of two upright posts and a cross-piece. They are used for belaying the larger ropes, such as the sheets and braces.

For belaying ropes in order of size, —

A riding-bitt.
A kevel.
A belaying-bitt.
A belaying-cleat.
A belaying-pin.

Bit'ter-end. (*Nautical.*) The part of the cable abaft the bitts. The last end of a cable in veering out. The clinching end.

Bitt-heads. (*Shipbuilding.*) The upright timbers bolted to several decks, and serving as posts to which the cable is secured. They correspond to *bollards* on a wharf or quay. *Knight-heads.*

Bit'ting-rig'ging. (*Saddlery.*) A bridle, surcingle, back-strap, and crupper. The bridle has a gag-rein and side-reins, the latter buckling to the surcingle. The rigging is placed on young horses to give them a good carriage, but must be released occasionally, as the best position of the neck and elevation of the head is unnatural, and takes time to acquire.

Bitt-stop'per. (*Nautical.*) A rope rove through a knee of the riding-bitt and used to clinch a cable.

Bi-zet'. (*Diamond-Cutting.*) The upper faceted portion of a brilliant-cut diamond which projects from the setting. It has one third of the whole depth of the gem, being cut in 32 facets, which occupy the zone between the *girdle* and the *table*. See BRILLIANT.

Black. The pigment which absorbs all the light rays is usually carbon in some form.

Charcoal is prepared by heating wood to redness in a position protected from the oxygen of the atmosphere.

Bone-black is prepared by the distillation of bone in retorts.

Animal charcoal is another name for *bone-black*.

Ivory-black is a bone-black obtained from cuttings, raspings, dust, and scraps of ivory.

Lamp-black is the soot obtained by collection from the burning of impure and refuse resinous matters and oils.

Spanish-black is the carbon of cork.

Peach-black is obtained from peach-stones.

Frankfort-black is the carbon obtained from the marc of grapes, wine-lees, peach-kernels, and bone-shavings.

German-black is another name for the Frankfort.

Vine-black is the carbon of the grapevine.

Graphite, also called *plumbago* and *black-lead* (misnomers), is a form of mineral carbon. See BONE-BLACK; CHARCOAL; LAMP-BLACK, etc.

Blackboard. A diagram board used in schools and lecture-rooms for the public demonstration of problems, the exhibition of examples, and the illustration of propositions in natural philosophy, etc. They are prepared by closely joining together well-seasoned boards planed smooth, and painting them with several coats of black paint mixed with finely pulverized pumice-stone or similar material, so as to impart a slight roughness to the face, that the chalk employed in writing may leave distinct marks on the board and yet rub off freely.

Black'en-ing. 1. (*Founding.*) An impalpable powder, usually charcoal, employed by molders to "dust" the "partings" of the mold.

2. (*Leather-Manufacture.*) A solution of sulphate of iron applied to the grain side of the skin while wet; it unites with the gallic acid of the tan, and produces a black dye.

Black Flux. (*Metallurgy.*) A material used to assist in the melting of various metallic substances. It is made by mixing equal parts of niter and tartar, and deflagrating them together. The black substance which remains is a compound of charcoal and the carbonate of potassa.

Black-ground Il-lu'mi-na-tor. (*Optical Instrument.*) One in which an opaque surface is introduced behind the object, while illuminating rays are directed around and upon it. For forms of this see SPOT-LENS; PARABOLIC ILLUMINATOR.

Black'ing. A composition for polishing leather.

Recipes. Liquid blacking: 1. Ivory-black, 5 oz.; treacle, 4 oz.; sweet oil, ¾ oz.; triturate until the oil is thoroughly mixed in; then stir in gradually ¼ pint each of vinegar and beer lees.

2. Ivory-black, 1 lb.; sperm-oil, 2 oz.; beer and vinegar each one pint, or sour beer 1 quart.

3. BRYANT and JAMES's patent india-rubber liquid blacking: india-rubber (in small pieces), 18 oz.; hot rapeseed-oil, 9 lbs. (1 gall.); ivory-black, in fine powder, 60 lbs.; treacle, 45 lbs.; add gum-arabic, dissolved in vinegar, 1 lb.; triturate the mixture in a paint-mill; place in a wooden vessel, and add 12 lbs. sulphuric acid; stir daily ½ hour for 14 days; then add 3 lbs. of gum-arabic, and repeat the stirring daily for 14 days, when the blacking will be ready for use.

Paste: —

Ivory-black	4 pounds.
Molasses	3 pounds.
Sperm-oil (hot)	9 ounces.
Gum-arabic	1 ounce.
Vinegar	12 ounces.

Mix; stir occasionally during 6 days. More vinegar will liquefy the compound.

The addition of sulphuric acid to ivory-black and

sugar produces sulphate of lime, and soluble acid phosphate of lime, which makes a tenacious paste.

Liebig's recipe: —

Ivory-black	8
Molasses	4
Hydrochloric acid	1
Sulphuric acid	2
Water	*ad. lib.*

Harness-blacking: 1. Glue or gelatine, 4 oz.; gum-arabic, 3 oz.; water, ¾ pint; dissolve by heat; add treacle, 7 oz.; ivory-black (in very fine powder), 5 oz.; and gently evaporate until of a proper consistency when cold, stirring all the time. To be kept corked.

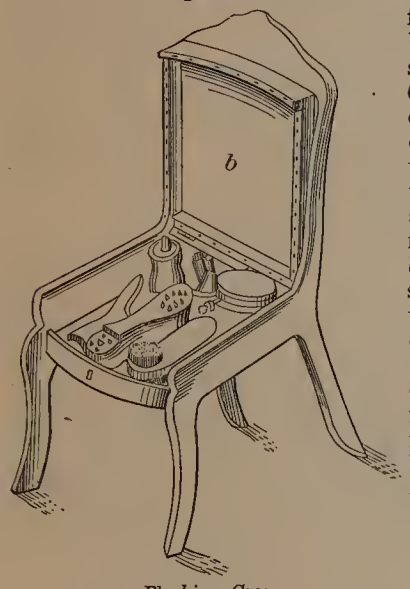
2. Mutton-suet, 2 oz.; beeswax, 6 oz.; melt, add sugar candy, 6 oz.; soft soap, 2 oz.; lampblack, 2½ oz.; indigo (in fine powder), ½ oz.; when thoroughly incorporated, add oil of turpentine, ¼ pint.

3. Beeswax, 1 lb.; ivory-black, ¼ lb.; prussian blue, 1 oz. (ground in linseed-oil, 2 oz.); oil of turpentine, 3 oz.; copal varnish, 1 oz.; mix well together, and form into cakes while warm.

4. To the last, while still hot, add soft soap, 4 oz.; oil of turpentine, 6 oz.; put into pots or tins while still warm.

Black'ing-brush. A brush for cleaning, blacking, or polishing boots; a stiff brush for removing dirt; a soft brush for applying the blacking, and a medium brush for polishing. A blacking and a polishing brush on the respective sides of the same brush-back is the usual arrangement.

Fig. 699.



Blacking-Case.

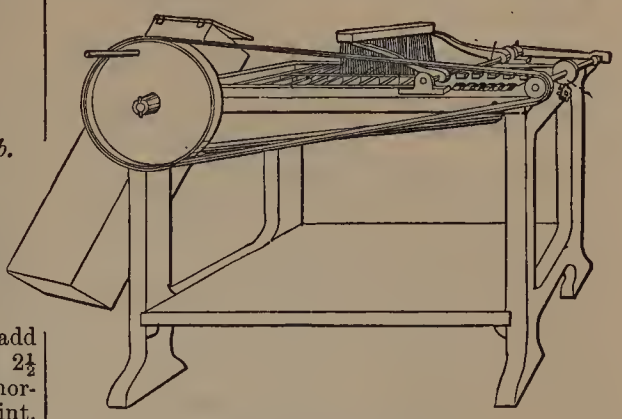
Black'ing-case. A case for blacking and brushes. That shown in Fig. 699 has a receptacle in the chair-seat which contains the appliances and also a foot-rest. The seat *b* is hinged, and serves as a cover to the receptacle.

Black-jack. (*Mining.*) A native sulphuret of zinc. Also known as *mock-lead*. See BLENDE.

Black-lead. A native form of carbon sometimes containing traces of iron. The terms *black-lead* and *plumbago* are misnomers, as the article has no lead in its composition, though it gives a mark like lead when drawn over a surface. *Graphite* is the preferable term, referring to its uses in writing and drawing. See GRAPHITE.

Black-lead'ing Ma-chine'. A machine for coating the surfaces of electrotype molds with plumbago. The carriage which supports the mold is moved gradually along the bed beneath the brush, which has a quick, vibratory movement in the same direction. The graphite, being sprinkled on the mold, is caused to penetrate the recesses of the letters in the matrix by the penetrating points of the bristles.

Fig. 700.



Black-Leading Machine.

Black-plate. The sheet-iron plate before tinning.

Black'smith's Chis'el. Blacksmith's chisels, for cutting iron bars, are divided into two principal classes, for hot and for cold iron, distinguished from each other by the different angles of the cutting edge, and by the former kind having a wooden handle inserted through an eye at right angles to the length of the chisel.

The hardy is a chisel having a tang fitting into a hole in the anvil. (See ANVIL.) When used upon hot iron, the chisel has a withe of hazel or other soft wood wound around it.

Black'smith's Tools. See the following: —

Anvil.
Barnacles.
Bar-shoe.
Battery-forge.
Beak.
Bellows.
Black-work
Bore.
Butteris.
Calking-anvil.
Calking-tongs.
Calking-tools.
Calking-vise.
Calk-sharpener.
Calk-swage.
Cautery.
Chisel.
Clincher.
Collar-tool.
Coupler.
Creaser.
Cutting-shoe.
Die.
Drift.
Foot-rest.
Forge.
Forge, Portable
Forging-machine.
Fuller.
Fullering-tool.
Hammer.
Hand-hook.
Hardy.
Hoof-spreader.
Horse-holder.
Horseshoe.
Horseshoe anvil.
Horseshoe machine.
Horseshoe nail.
Horseshoe nail-machine
Horseshoe vise.
Jam-weld.
Jumping.
Lunette.
Mandrel.
Miter-iron.
Monkey.
Oliver.
Ox-shoe.
Pliers.
Porter.
Prick-punch.
Pritchel.
Punch.
Riveting-tools.
Rounding-tool.
Searing-iron.
Slake-trough.
Sledge.
Snap-head.
Stifle-shoe.
Stock.
Stock and dies.
Stocks.
Striker.
Swage.
Swage-block.
Tap.
Tilt.
Tilt-hammer.
Tire-bender.
Tire-heater.
Tire-shrinker.
Toe-calk.
Tongs.
Top-tool.

Triblet.
Tuyere.
Twitch.
Upsetting-machine.
Welding-swage.

Black-strake. (*Shipbuilding.*) The strake next below the lower or gun-deck ports.

Black Tin. (*Mining.*) Tin ore, washed and dressed, beaten into a black powder, and ready for smelting.

Black-wall' Hitch. (*Nautical.*) A bend to the back of a tackle-hook or to a rope, made by passing the bight round the object and jamming it by its own standing part. See HITCH.

Black-work. The work of the blacksmith in contradistinction to bright-work or the work of the silversmith.

Blade. In a mechanical sense this is a sharp instrument, relatively long, thin, and flat. It is applied to objects which have the proportions of a knife or sword, such as the sharp-edged beaters in hemp or flax brakes, the cutters in some descriptions of corn-harvesters, and to other objects which have the function of knives or cutters.

A *blade*, in usual parlance, is that of a knife, sword, axe, adz, saw, and is less frequently applied to the tools which are driven endwise, such as the chisel and gouge.

1. (*Nautical.*) *a.* The part of the anchor-arm which receives the palm, forming a ridge behind the latter.

b. The *wash* of an oar; that part which is dipped in rowing.

2. The *web* of a saw.

3. (*Weapon.*) *a.* The *blade* of a bayonet consists of the

Point,
Back,
Flat,
Fullers or *grooves.*

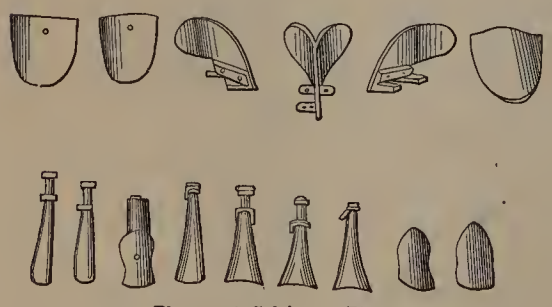
b. The flat metallic portion of a knife or sword which is secured in the *handle* or *hilt* by a *tang.*

The blade of a sword consists of the
Shoulder; at the junction of the tang.
Forte; half the blade nearest the guard.
Foible or *faible;* half the blade nearest to the point.

Tang.
Point.
Back.
Flat.
Edge.

4. (*Agriculture.*) The share of a shovel-plow, cultivator, or horse-hoe. These are of various forms.

Fig. 701.



Plow and Cultivator Blades.

5. (*Shipwrighting.*) The float or vane of a paddle-wheel or propeller.

Blanc'ard. (*Fabric.*) A linen cloth of Normandy, made of half-bleached thread.

Blan'chard Lathe. A lathe for turning irregular forms, invented by Thomas Blanchard. It was the first successful lathe for turning gun-stocks, axe-handles, shoe-lasts, etc. The idea was partly elicited in Brunel's block-turning machine. See BLOCK-MAKING MACHINE; LATHE.

Blanched Cop'per. (*Metallurgy.*) An alloy composed of copper, 8 oz., and ½ oz. of neutral arsenical salt, fused together under a flux of calcined borax, charcoal-dust, and fine powdered glass.

Tin or zinc is added in the white *tombac* of the East Indies,—*mock silver.*

Blanch-im'e-ter. An instrument for measuring the bleaching power of a chloride. See CHLORIMETER.

Blanch'ing. (*Metallurgy.*) Tinning of copper.

Blank. 1. (*Architecture.*) *Blank doors* or *blank windows* are imitations, and used for ornamentation or to secure uniformity in the design.

2. (*Metal-working.*) *a.* A piece of metal brought to the required shape and ready for the finishing operation, whatever it may be.

b. A *planchet* of metal, weighed, tested, and milled, is a *blank* ready for the die-press, which converts it into a *coin.*

c. A strip of softened steel made into the required shape is a *blank*, which cutting and tempering transform into a *file.*

d. A piece of iron with a flaring head, and otherwise properly shaped ready for nicking and threading, is a screw-blank, which with the final operations becomes a screw.

The list might be prolonged, but the above is sufficiently indicative.

Blank-car'tridge. An inclosed charge of powder without shot. Used for firing warnings or salutes and in exercising troops.

Blank-cut'ting Ma-chine'. (*Metal-working.*) A machine for cutting out pieces of metal for fabrication into articles; such as keys, files, buttons, etc.

Blank'et. 1. (*Fabric.*) A coarse, heavy, open, woolen fabric, adapted for bed covering, and usually napped. It may be twilled or otherwise. A name applied to any coarse woolen robe used as a wrapping.

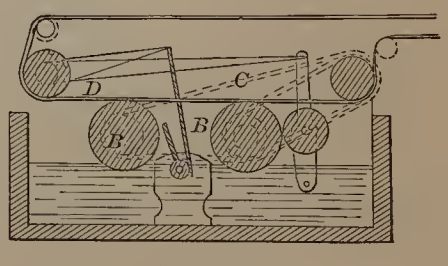
> "Antiphanes, that witty man, says:
> 'Cooks come from Elis, pots from Argos,
> Corinth blankets sends in barges.'"
>
> ATHENÆUS (A. D. 220).

The *poncho* is a blanket with a hole in the center for the head to go through. It is worn by the South Americans, Mexicans, and Pueblo Indians.

2. (*Printing.*) A piece of woolen, felt, or prepared rubber, placed between the inner and outer tympans, to form an elastic interposit between the face of the type and the descending platen.

Blank'et-wash'er. A machine for washing printer's blankets. Ordinarily it consists of a vat

Fig. 702.



Blanket-Washer.

and rollers, the blanket being alternately soaked and squeezed. In the illustration a scraper or *doctor* is used to clean the roller. A similar machine is used for calicoes and other fabrics.

Blank-tire. A tire without a flange.

Blare. (*Nautical.*) A paste of hair and tar for calking the seams of boats.

Blast. 1. (*Metal-working.*) An artificial current of air to urge a fire; as, *hot-blast; cold-blast.*

2. (*Engineering.*) The exploding of a bursting charge, for rending rocks, etc. See BLASTING.

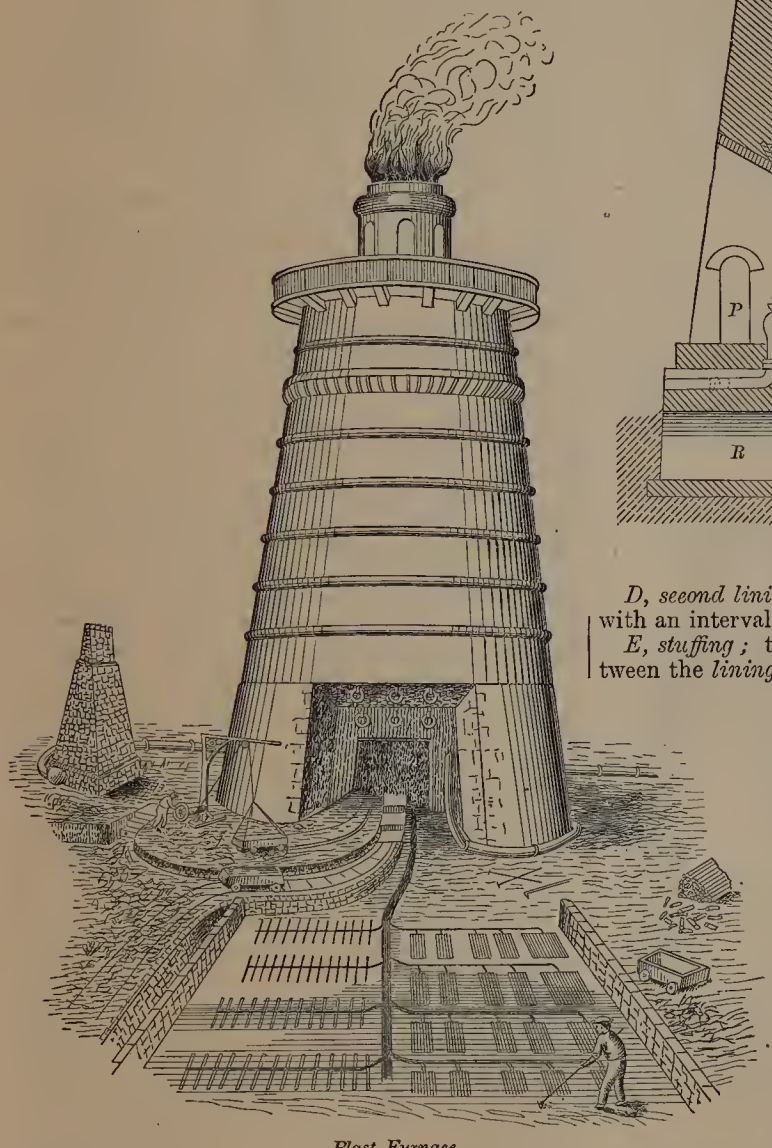
3. (*Steam-Engineering.*) Exhaust steam directed up a chimney to urge a fire.

Blast-en'gine. (*Pneumatics.*) *a.* A ventilating machine on shipboard to draw foul air from below and induce a current of fresh air.

A machine for urging the fire of a furnace. See BLOWER.

Blast-fur'nace. (*Metallurgy.*) A furnace into which a current of air is artificially introduced, to assist the natural draft or to supply an increased amount of oxygen to a mineral under treatment.

Fig 703.



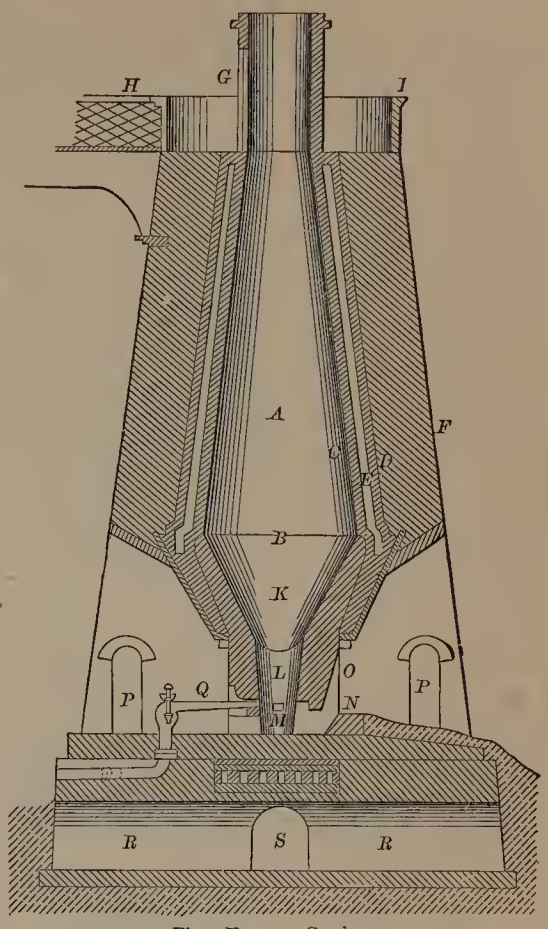
Blast-Furnace.

Fig. 703 is a perspective view of the furnace. The hot-blast apparatus is seen at the left. In front is the sand-bed, into which the metal flows to form pigs.

The parts of a blast-furnace are named as follows: —

A, shaft, fire-room, tunnel; the internal cavity.
B, belly; the widest part of the shaft.
C, lining, shirt; the inner coat of fire-bricks.

Fig. 704.



Blast-Furnace Section.

D, second lining, easing; an outer casing of brick with an interval between it and the former.

E, stuffing; the filling of sand or coke-dust between the *lining* and *casing.*

F, mantle, outer-stack, building; the outer wall of masonry.

G, mouth, furnace-top; the opening at top for the ore, coal, and limestone.

H, landing, platform; the stage or bank at the furnace *mouth.*

I, wall, crown, dome; the wall around the furnace-top.

K, boshes; the lower part of the furnace descending from the *belly.*

L, hearth; the pit under the boshes, by which the melted metal descends.

M, crucible; the hearth in which the cast-iron collects. The lowest part is the *sole.*

N, dam; a stone at the end of the fire-hearth.

Tap-hole; an opening cut away in the hardened loam of the dam.

O, tymp-arch, working-arch, folds, faulds; the arch of the *mantle* which admit to the *fire-hearth.*

P, tuyere-arch, twyer-arch; arch of the mantle which leads to the *tuyeres.*

Q, tuyere, twyer, twere; the cast-iron pipe which forms the nozzle for the blast.

R, S, arches for ventilation.

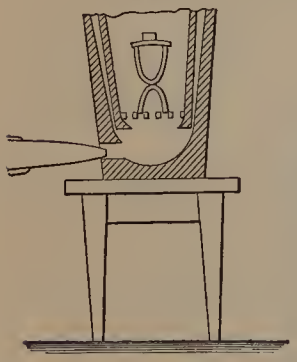
T, channels in the masonry for the escape of moisture.

A large Welch blast-furnace contains 150 tons of ignited material (iron-ore, coke, and limestone-flux), and requires 20,000 cubic feet of air per minute. The weight of the air thrown into the furnace every 24 hours is nine times the weight of the charge of fuel, ore, and flux.

Blast-furnaces are now built as much as 103½ feet high, 27½ feet at the bosh, and 8 feet at the hearth. The average make of such a furnace is 550 tons weekly. The consumption of coke is 16 cwt. per ton of iron made, and 9¼ cwt. of limestone per ton of iron when forge-iron is produced. The blast is supplied by six tuyeres to each. A cast-iron pipe is carried around each surface, from which smaller pipes branch off at equal distances to the tuyeres. These pipes are covered by a non-conducting composition, but wrought-iron pipes may be used in place of these, lined with fire-brick inside four inches in thickness. The furnaces are plated outside, and closed at the top on the cup and cone principle. The blowing-engine for the two furnaces has a 67-inch steam-cylinder, 130-inch blowing-cylinder, 10½ foot stroke. The stoves used heat the blast to 1,400°. Four stoves are required for each furnace. Each stove has two rows of pipes; there are nine double pipes in each row, 11 feet in length; the pipe is of the flat form, the two passages in each being 13 inches by 4 inches inside, divided by a partition 1 inch thick, the whole of the metal being of that thickness, which renders them much lighter than the old form of pipes.

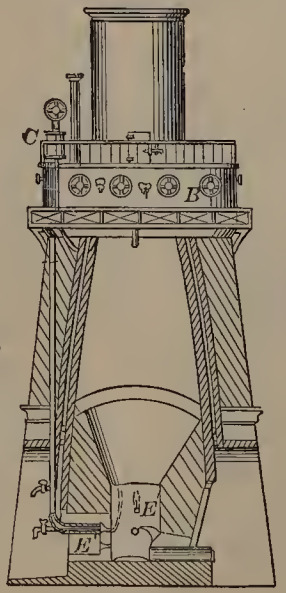
The blast enters at one side of a row of pipes, and must pass through nine double pipes before it makes its exit at the other side. The figures apply to the Cleveland ore, England. See SMELTING.

Fig. 705.



Laboratory Blast-Furnace.

Fig. 706.

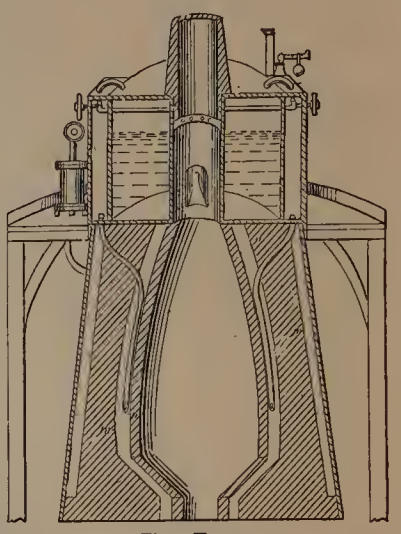


Blast-Furnace.

A small blast-furnace for the laboratory, such as that used by Faraday at the Royal Institution, consists of an outer pot, which is bored for the nose of the bellows, and an inner pot, whose bottom was cut off and the interior fitted with a grating. Pounded glass-pot powder was packed while wet in the interval between the two pots. The fuel is coke. The outer pot is 18 inches high and 13 inches external diameter. The inner pot has 7½ internal diameter at top and 5 inches at bottom.

Fig. 706 shows a view, partly in section, of an arrangement in which an annular boiler surmounts the ore-chamber of the furnace, and its steam passes by a pipe to a tube, where it is associated with a hot-blast from an air-pump, and the combined fluids are driven through the tuyeres into the furnace. The air-pump *C* keeps up a uniform blast, and is itself driven by the steam from the boiler *B*. Hot air and superheated steam are mingled and injected into the furnace at the tuyeres *E' E'*.

Fig. 707.



Blast-Furnace.

Fig. 707 shows a somewhat different form of furnace, with the boiler in section. The jacket-boiler surmounts the ore-chamber, forming the tunnel-head of the furnace. An inclined chute passes through the boiler, and is the means of supplying the ore and coal. The pipes conducting the steam are laid in cement.

Blast-hearth. (*Metallurgy.*) The Scotch ore-hearth for reducing lead ores.

Blast-hole. (*Hydraulics.*) The induction water-hole at the bottom of a pump-stock.

Blast'ing. The process of rending rocks, etc., by means of boring, filling the hole with an explosive, and then firing it off. Improvements appertain to the modes of drilling the holes, the composition of the explosive, and the means of igniting.

Gunpowder is said to have been first used for blasting in Germany or Hungary, A. D. 1620; and some German miners, brought to England by Prince Rupert, introduced the practice at the copper mine of Eckford, in Staffordshire, the same year.

The preliminary operation in blasting consists in boring or drilling holes, in which are to be placed the charges of gunpowder or other explosive materials employed to rend the rock.

The implements ordinarily used for this purpose are the jumper, or drill, the hammer, and the scraper. The jumper is a bar of iron, in length proportioned to the depth of hole to be bored, and is faced with steel for a part of its length: those of 1½ inches diameter and upward are worked by three men, two of whom strike alternately on the end of the jumper with hammers, while the third turns it so as to constantly present the cutting edge to a fresh surface of stone.

This is a slow and laborious operation, experience having shown that in granite three men working as above with a jumper of 3 inches diameter, such as is used for boring holes from 9 to 15 feet deep, would not penetrate more than about 4 feet per day on an average; or with a 2½-inch jumper, 5 feet per day, the last being employed for holes from 5 to 10 feet deep.

Churn-jumpers are so called from the manner in which they are worked, by a vertical churning or pounding movement, no hammer being employed; they have a steel bit at each end, are usually worked by two men, and are generally of smaller diameter than those which are worked by a hammer; in drill-

ing holes that are vertical or nearly so, and in moderately hard rock, they are found more advantageous than the others, two men being able to bore about 16 feet per day with a churn-jumper of 1⅛ to 1½ in diameter. They are sometimes used with a spring rod and line, much in the manner of the most primitive way of boring artesian wells.

General Burgoyne mentions seeing the same device in use in blasting the calcareous rocks of Marseilles, at the foot of the hill on which the fort of Notre Dame de la Garde now stands.

The common way of charging the hole is, where the moisture is not excessive, to pour loose powder into it to a certain depth, depending on the judgment of the miner (one third the depth of the hole is a common allowance under ordinary circumstances); the needle, which is a wire sufficiently long to reach well down into the charge of powder, and provided with a handle to enable its easy withdrawal, is then inserted and the hole tamped, a wad of hay, straw, dry turf, or other suitable material, being first placed over the powder; the tamping is performed by ramming down small fragments of broken brick or of stone which does not contain silex to endanger striking fire, by means of an iron bar called a tamping-rod; when the hole is tamped nearly up to the level of the ground, an inch or two of moist clay is usually placed over the tamping, and the needle withdrawn; it may be remarked that the needle should be frequently turned as the ramming proceeds, so that it may be withdrawn without disturbing the tamping. The priming is effected by pouring fine grained powder down the hole left by the needle, or, what is better, straws filled with powder are pushed down, communicating with the blasting charge; a bit of slow-match or touch-paper, calculated to burn long enough to allow the workmen to retire to a place of safety, is then ignited, and placed in contact with the priming.

In the construction of the Southeastern Railway 400,000 cubic yards of compact chalk were lifted from the face of the Round Down Cliff, two miles west of Dover, England, at a single blast.

Three charges were employed, placed in chambers, 70 feet apart, the center and largest one being placed at a salient point 72 feet, and those on each side each 56 feet distant from the face of the cliff. The charges of powder were 7,500 lbs. in the main chamber, and 5,500 lbs. in each of the others. Shafts tapering from bottom to top were driven downward from a driftway previously cut in the rock, and from the bottoms of these shafts galleries were cut at right angles to the driftway. These were also enlarged at their inner extremities, to secure the tamping. The chambers were cut at right angles to the galleries. After charging, a dry wall of chalk was built across the mouths of the chambers; the galleries and shafts were tamped with the same material, and the tamping was extended into the driftway 10 feet on each side of each shaft. Three Daniell's batteries and three sets of wires were used for firing the mines, which was done simultaneously. The mass of rock removed averaged 380 feet in hight, 360 in length, and 80 in thickness. See ARTESIAN-WELL; TUNNEL; WELL-BORING; and Specific Indexes under CIVIL ENGINEERING and MINING.

See Raymond's "Mines, Mills, and Furnaces": J. B. Ford & Co., N. Y., 1871. Blake's "Mining Machinery": New Haven, 1871. Also, "Blasting and Quarrying of Stone and Blowing up of Bridges," by Lieutenant-General Sir J. Burgoyne of the English Military Engineers. No. 35 of Weale's Rudimentary Series: London.

The following table from General Sir Charles Pasley's "Memoranda on Mining" will give the means of calculating the space occupied by any given quantity of powder in round holes of different sizes, from one to six inches: —

Diameter of the hole.	Powder contained in one inch of hole.		Powder contained in one foot of hole.		Depth of hole to contain 1 lb. of powder.
Inches.	lb.	oz.	lb.	oz.	Inches.
1	0	0.419	0	5.028	38.197
1¼	0	0.942	0	11.304	16.976
2	0	1.676	1	4.112	9.549
2½	0	2.618	1	15.416	6.112
3	0	3.770	2	13.240	4.244
3½	0	5.131	3	13.572	3.118
4	0	6.702	5	0.424	2.387
4½	0	8.482	6	5.784	1.886
5	0	10.472	7	13.664	1.528
5½	0	12.671	9	8.052	1.263
6	0	15.080	11	4.960	1.061

The following table shows the quantity of powder required to lift from its bed rock of usual weight (about 1¾ tons to the perch) and ordinary consistence.

Line of least resistance.	Charges of powder.		Line of least resistance.	Charges of powder.	
Feet.	lb.	oz.	Feet.	lb.	oz.
1.0		¼	4	2	0
1.6		1¾	4.6	2	13½
2.0		4	5	3	14¼
2.6		7¾	6	6	12
3.0		13¼	7	10	11¼
3.6	1	5¼	8	16	0

The obstruction known as Blossom Rock in the harbor of San Francisco was removed by constructing a coffer-dam around a portion of the rock, a porous sandstone, and excavating its interior, leaving a shell about 6 feet thick, supported by props, to resist the pressure of the water. The space excavated measured 140 by 50 feet, and varied in depth from 4 to 29 feet. 23 tons of powder were used, part of which was inclosed in water-proof casks, and the remainder in iron tanks. These were connected by insulated wires with an electric battery. When all was ready, the coffer-dam was removed, and the water permitted to fill up the excavation, acting as a tamping. The result is represented to have been entirely successful.

Maillefert's process in removing *Way's Reef* in the Hurl-Gate (Hell Gate) obstruction, on the East River, N. Y., consisted in depositing a quantity of powder on the surface of the rock to be removed, and then exploding it. There is no cumbrous apparatus used. A sounding-pole to ascertain the depth, a boat to contain the operators, and an electric battery, are the machinery employed. The explosion is effected by electricity, and it is the same thing whether the operators are stationed near or far, they need never be in danger.

The force of the current is such as to render it difficult to fix drilling apparatus. The process was successful on prominences and to a certain extent; where a broad area was flat, the value of the process rapidly diminished.

Shelburne's apparatus on the *Frying-pan Rock*, in the same estuary, was a heavy stamping-drill, operated by a steam-engine, and acting in a tube which directed its blows; the hole obtained receiving a charge of nitro-glycerine.

The work of removing the obstructions in the East River has now devolved upon the United States Engineers, under General Newton. They are proceeding by building coffer-dams and driving headings. It is a regular tunneling business, and when the whole

roof is blown off and the pillars broken off, the new river-bottom will be the bottom of the drifts, plus what of the rock may fall back into the hole. Such can be grappled and removed.

Nitro-glycerine, dualin, dynamite, and various other compounds of terrific energy, are used in these great engineering projects. It is understood that nitro-glycerine has been the principal agent in the Mount Cenis tunnel, as it has been for some years past in the Hoosac.

The idea of blasting by a torpedo in the bottom of an oil-well, to open crevices and increase the flow of oil, seems to have been entertained by a number of persons, including Professor Hare, but was reduced to practice by Colonel Roberts. See TORPEDO.

Blast'ing-fuse. The common blasting-fuse is merely a tube filled with a composition which will burn a sufficient length of time to allow the person firing it to reach a place of safety before it is burnt out.

Safety-fuse, by which the charge can be fired by a man at a considerable distance, is also generally employed. Some of these consist of a tape of soft material saturated with a highly inflammable compound (fulminates are, we believe, employed in some to increase the speed of the flame), and covered with an envelope of waterproof material. Firing by electro-battery is much safer.

Blast'ing-nee'dle. A long taper piece of copper, or iron with a copper point; used when tamping the hole for blasting, to make by its insertion an aperture for a fuse or train.

Blast'ing-pow'der. It was formerly thought that a slow-burning powder, containing a comparatively small proportion of niter, — about 62 per cent, — was more effective for blasting purposes, allowing more time to produce a rending effect upon rock before being consumed than the quicker and stronger powder used in fire-arms; but the tendency now is toward the use of substances of far greater rapidity of ignition, and greater expansion in the act of assuming the gaseous state, than even the strongest gunpowder.

Among more than thirty patented compositions for blasting powder are the following ingredients. The specific combination in each case might be given would space permit.

1. Forms of carbon: —

Burnt cork.	Gambier.
Charcoal.	Brown coal.
Lycopodium.	Peat.
White sugar.	Logwood.
Sawdust.	Bark.
Horse-dung.	Carbolic acid.
Starch of flour.	Aloes.
Petroleum products.	Paraffine.
Cutch.	Fatty matters.
Tannin.	Resins.

2. Metallic salts, etc.: —

Chl. potash.	Carbonate of soda.
Red sulph. arsenic.	Nitrate of lead.
Ferro-cyan. potassium.	Ammoniacal salts.
Nitrate of potassa.	Nitrate of soda.
Sulphur.	Carbazotate of potash.
Chloride of sodium.	Azotate of potash.
Cyanuret of zinc.	Nitrate of iron.
Barilla.	Nitric acid.

Blast'ing-tools. Baron Liebhaber of Paris obtained a patent in France, 1845, for a mode of enlarging the lower part of a blast-hole by the application of muriatic or other acid 1 part, diluted in water 3 parts.

A tube (*k*, Fig. 708) is inserted in the hole and externally sealed around the lower end with a composition which prevents the rising of the vapors of the acid in the space between the tube and the sides of the hole. The acid is poured into a funnel and down an inner tube, the annular space forming a duct for the escape of the gas, the spent liquid escaping at a bent spout. The hole is then emptied by a siphon or pump, and dried to prepare it for the charge.

The principal blasting tools are —

The *hammer*, for striking the borer.

Borer, or *jumper*. *Drill*.

Gad; a wedge for driving into openings made by a pick.

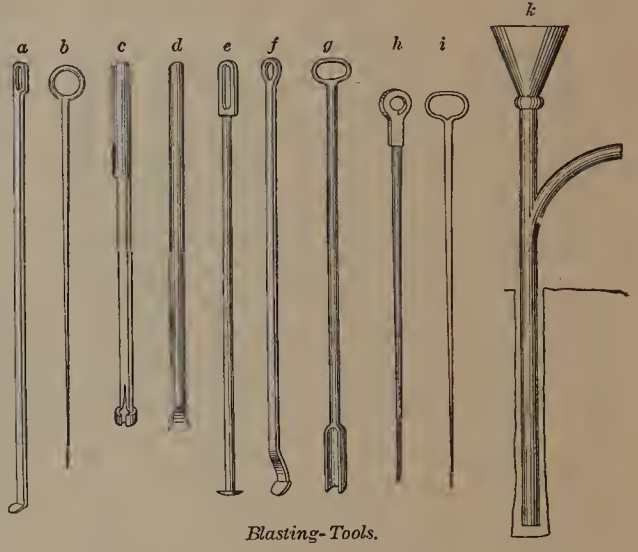
Pick.

Scraper; for clearing the hole.

Needle, or *priming-wire*; a thin copper rod whose withdrawal leaves a vent whereby the charge is reached.

Claying-bar, *tamping-iron*, or *rammer*; for driving down the tamping.

Fig. 708.



Blasting-Tools.

The *fuse*, or *match*.

a e f, scrapers for clearing the blasting-hole.

b h i, needles for pricking the cartridge.

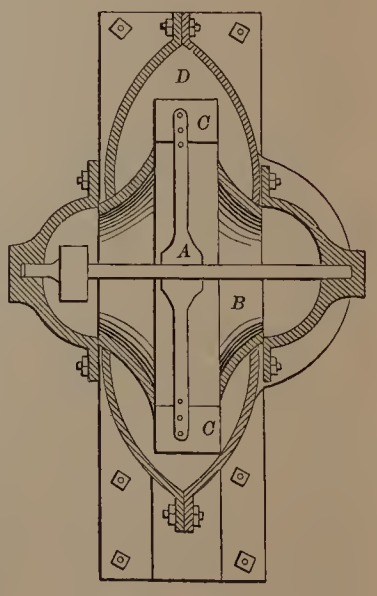
c, tamping-bar.

d, drill.

g, bar for ramming in the cartridge.

k, funnel and pipe for introducing acid to enlarge the bottom of the hole.

Fig. 709.



Blast-Machine.

Blast-ma-chine'. (*Pneumatics.*) A fan *A* inclosed within a box *B*, to which the wings *C* are attached, so that the whole revolves

together. It is closely fitted within a stationary exterior case *D*, into which it is journaled. Air is admitted at the sides around the axis, and forced out through an aperture at the periphery by the rapid rotation of the fan, which may, by belt and pulley connections, be driven at the rate of 1,800 revolutions per minute. See BLOWER.

Blast-me'ter. (*Pneumatics.*) An anemometer applied to the nozzle of a blowing engine.

Blast-noz'zle. The orifice in the delivery-end of a blast-pipe. A *tuyere.*

Blast-pipe. (*Steam-Engine.*) A pipe conveying the escape-steam from the cylinders up the smoke-stack of the locomotive to aid the draft. Its invention is ascribed to George Stephenson.

Blaz'ing Com'et. A form of pyrotechnics.

Blaz'ing-off. (*Metal-working.*) Tempering by means of burning oil or tallow spread on the spring or blade, which is heated over a fire.

Bleach'ing. The art of removing color from fabrics, etc. It was known in India, Egypt, and Syria, and in ancient Gaul.

As at present practiced, the process dates back only to the beginning of the present century.

Linen was formerly sent from England to Holland to be bleached. This was performed by several months' exposure to air, light, and moisture. The linens were spread on the ground and sprinkled with pure water several times daily. They were called Hollands, and the name still survives.

In 1749 the system of *bucking* and *crofting*, that is, soaking in alkaline lye and spreading on the grass, was introduced into Scotland. After five or six repetitions of these processes, the linen was dipped in sour milk and then *crofted.* The processes were repeated. The cotton manufacture at this time was in its earliest infancy.

The next improvement was the substitution of dilute sulphuric acid for sour milk. This reduced the time one half.

Scheele, in 1774, had discovered chlorine; and Berthollet, in 1784, ascertained that an aqueous solution of chlorine discharged vegetable colors. This he communicated to Watt, and it was soon adopted in Scotland with linen. Berthollet added potash to the water to preserve the health of the workmen and the texture of the goods.

Dr. Henry, of Manchester, substituted lime for potash, the goods being passed through a cream of lime and then exposed to chlorine. This formed a chloride of lime on the cloth.

In 1798, Tennant, of Glasgow, adopted a saturated solution of chloride of lime, and subsequently impregnated dry lime with the gas, making bleaching powder.

Bleaching, of cotton goods especially, is conducted on a systematic large scale, and includes singeing and washing; the former to remove the fibrous down from the surface, and the latter to remove the dirt and impurities acquired in spinning and weaving.

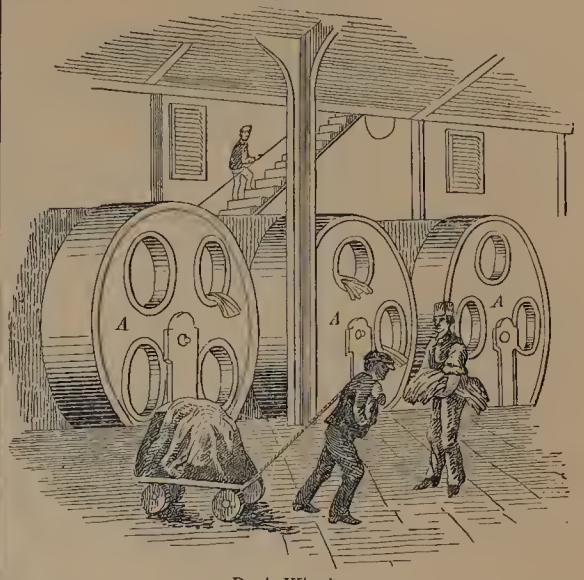
The following process is employed for cotton goods: —

In singeing, the cloth is passed rapidly over a red-hot roller, which removes protruding fibers.

The cloth is then placed in the dash-wheels *A A A* (Fig. 710), which rotate on horizontal axes, and have quadrantal compartments which hold the cloth. Water is introduced through the hollow axes, and a rapid rotation subjects the cloth to the combined effects of agitation and the dashing of the water.

The cloth is next *bucked*, or washed by an alkaline solution which removes the greasy and resinous matters. The goods are placed on the grated bottom of a vat, in the center of which is a stand-pipe by which the stream of boiling alkaline solution is brought in a shower upon the cloths. A deflecting plate on

Fig. 710.



Dash-Wheels.

the top of the stand-pipe distributes the water upon the cloths, through which it percolates and finds its way down through the grating, to be again pumped up. See BUCKING-KIER.

This shower of boiling alkaline solution is maintained for about seven hours, after which the cloth is again washed in the wheels.

The cloths are now *chemicked* by steeping for six hours in a dilute solution of chloride of lime, after which they are steeped in what is called a *souring* vat; this is a bath of very dilute sulphuric acid, which disengages the chlorine from the lime, and brings the gas into intimate contact with the fiber, which is thereby *bleached.*

The washing, boiling, bleaching, and souring are repeated as may be necessary to produce the complete effect.

The process takes from 24 to 48 hours, and the cloths are handled by machinery.

Linen is now bleached in a similar way, but the operation is more troublesome and requires a longer time, on account of the greater affinity of the material for coloring matter.

Wool is bleached by exposing it to the action of fuller's-earth and soap in a fulling-mill, after which it is washed and dried. When it is intended to preserve it white, it is usually run through water tinged with indigo, or exposed to the fumes of burning sulphur. The last method, unless very carefully conducted, is apt to cause the goods to acquire a harsh feeling, which is removed by washing in soap and water, but this usually reproduces the original yellowish-white tinge.

Silk is bleached by boiling in white soap and water, and then carefully rinsing it. When required to be very white, the material is usually subjected to the fumes of burning sulphur. Straw is generally bleached by the fumes of sulphur, but oxalic acid or chloride of lime is preferable.

Bleach'ing Pow'der. Chloride of lime.

Bleb'by-glass. Glass with blisters and air-bubbles.

Bleed'ing. (*Bookbinding.*) Cutting into the printed matter of a book when cutting the edges.

Blende. (*Mining.*) Otherwise known as *black*

jack. A native sulphuret of zinc, which is treated by roasting, and destructive distillation in combination with charcoal in a vessel from which the air is excluded.

By access of air the metal burns and passes off as the white oxide, which is collected and forms a pigment known as zinc-white.

Bleu-tur'quin. A kind of marble taken from the quarries of Genoa and elsewhere. It is of a deep blue upon a white ground, mixed with gray spots and large veins.

Blind. For apparatus to assist the *blind* in writing, printing, or reading, see EMBOSSING-TYPE FOR THE BLIND; PRINTING FOR THE BLIND; WRITING-FRAME.

Grenville's invention (English) for teaching the blind was in 1785.

1. (*Carpentry.*) A sun-screen or shade for a window.

Outside blinds are known as *Spanish, Florentine, Venetian*, or *shutter*.

Inside blinds are known as *Venetian, dwarf, spring, common roller, wire-gauze, perforated zinc*, etc.

2. (*Fortification.*) A bomb-proof shelter for men or provisions. *Blindage; blinded cover*.

3. (*Harness.*) Flaps on a driving-bridle to restrain the horse from looking sideways or to the rear. A modern form of blinder only prevents the backward view. *Blinder; blinker*.

Blind'age. 1. (*Fortification.*) *a*. A screen of wood faced with earth as a protection against fire.

b. A *mantelet*. At Sebastopol the Russians used blindages for covering their embrasures, composed of a grating of iron rods covered with canvas.

2. (*Harness.*) A hood for covering the eyes of a runaway horse, as a means of stopping him. KOEHLER'S patent has one strap which pulls a hood over the eyes and another which closes the nostrils. Another device is a choke-strap connected through the gag-loop to the driving-rein.

Blind A're-a. (*Architecture.*) A space around the basement-wall of a house to keep it dry.

Blind Ax'le. An axle which runs, but does not communicate motion. It may form the axis of a sleeve-axle. It may become a *live* axle at intervals. A *dead axle*.

Blind-block'ing. (*Bookbinding.*) The ornamentation of book-covers by pressure of an engraved or composed block with heat but without gold-leaf.

Blind Bri'dle. A bridle having attached flaps or blinds. See BLIND.

Blind Buck'ler. (*Nautical.*) A hawse-hole stopper.

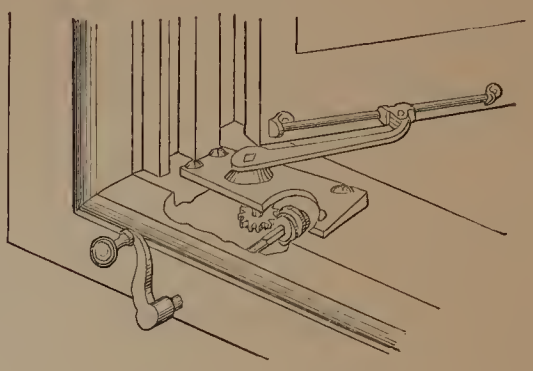
Blind'ers. (*Harness.*) Flaps over the eyes of a horse used in carriage-harness. See BLIND.

Blind'ing. A coating of sand and fine gravel, usually about an inch and a half deep, laid over a newly paved road, to fill by degrees the joints between the stones.

Blind Lev'el. (*Mining.*) A level or drainage gallery which has a vertical shaft at each end, and acts as an inverted siphon.

Blind Op'e-ra-tor. A device by which the blind may be opened or closed from the inside, and held in any position desired, either closed, fully open, or at any intermediate position, in all of which it may be securely locked. Attached to the frame of the blind is a rod upon which slides a sleeve pivoted to the outer end of an arm secured to the axis of a worm-gear seated in a recess in the window-sill and gradually rotated by a worm, the whole covered by a metallic plate.

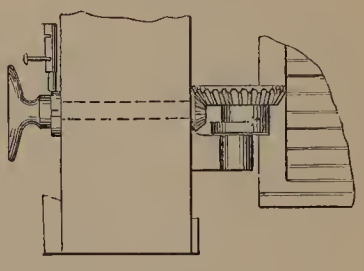
Fig. 711.



Blind and Shutter Fastener.

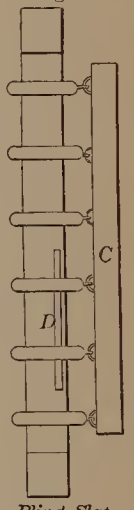
In another form, the pintle of the blind-hinge has a bevel-wheel operated by a bevel-pinion on the shaft, which passes through the frame of the window-easing, and has a knob inside the room. A bolt engages a disk on the shaft, and locks the latter, and consequently the blind, in any position.

Fig. 712.



Blind-Operator.

Fig. 713.



Blind-Slat.

Fig. 714.

Blind-Slat Chisel.

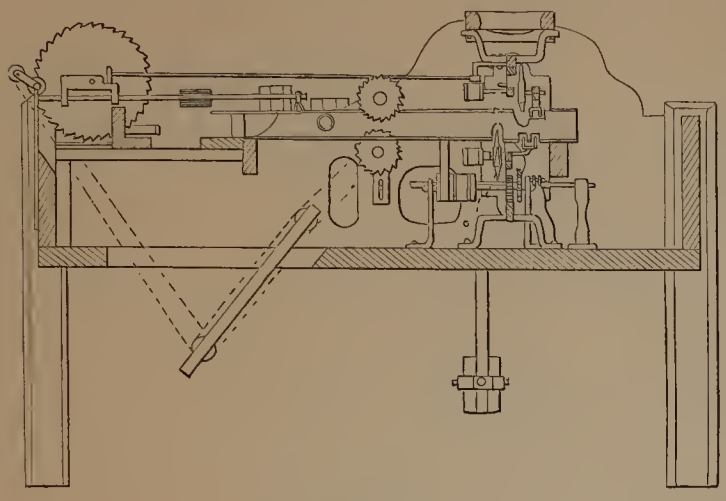
Blind-slat. An obliquely-set slat in a shutter, serving to shed rain and yet admit some light. In some cases they are adjustable by means of a bar *C*, which is secured by staples to the edges of the slats. *D* is a spring to press against the slats and hold them to adjustment. Such shutters are known as *Venetian* or *Louver*.

Blind-slat Chis'el. A hollow chisel, specially adapted for cutting the mortises in a common blind-stile for the reception of the ends of the slats.

Blind-slat Cut'ter. (*Carpentry.*) A machine which cuts blind-slats from the plank and finishes the sides and ends.

The plank is placed within the ways and fed along till it touches a stop, when a transverse cut severs a section, which is removed by a feed-roller to the place where it is sawed into strips. The action of the roller is intermittent, and during its intervals of rest the rotary tubular cutters are successively forced into the opposite sides of the block and form openings. The surfaces are planed and gudgeons made on their extremities by automatic operations.

Fig. 715.



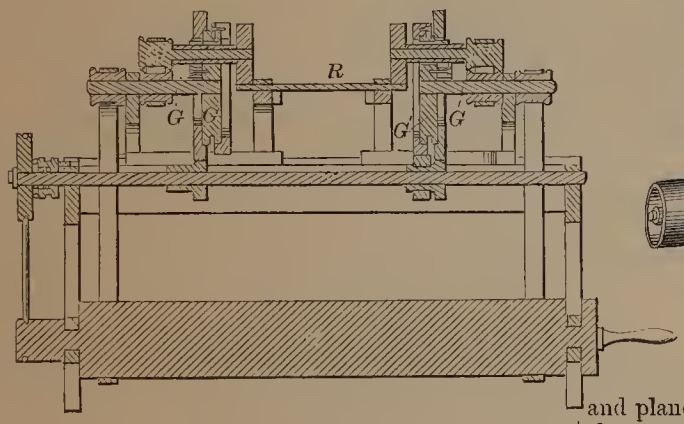
Blind-Slat Cutter.

Blind-slat Plan'er. (*Carpentry.*) A wood-planing machine with side and edge cutters adapted to act upon a narrow slat suitable for Venetian shutters and blinds. The cutter which acts upon the upper side is adjustable to adapt it for making slats of the required thickness; the edge-cutters have a shape to give the rounded edge, and one of them is adjustable as to distance, to make slats of the required width.

There are several patented machines of this class.

Blind-slat Ten'on-ing-ma-chine'. (*Carpentry.*) A machine for cutting tenons on the ends of blind-slats where they are to enter the stiles of the blinds. (Fig. 716.)

Fig. 716.



Blind-Slat Tenoning-Machine.

As the disks *G* rotate, they carry around the cutter-heads, whereby a tenon is cut upon each end of the blank slat. As soon as the blank *R* is inserted, the operator, by means of a clutch, causes the cutter-heads to revolve entirely around the ends of the slat, when they are arrested until the finished blank is removed and a new blank inserted. The cutter-head, may be set towards or away from the center of the disk-shafts, in order to cut larger or smaller tenons. The cutter-heads have a rotary movement upon their own axes, and also revolve around the axes of their supporting disks.

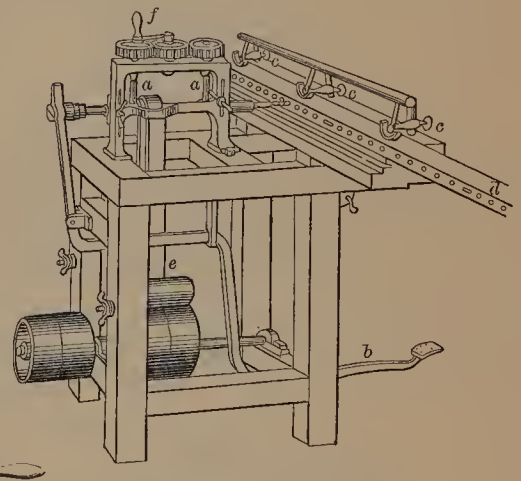
Blind-stile Bor'ing-ma-chine'. (*Carpentry.*) A machine for boring in blind-stiles the holes for the reception of the tenons on the ends of the slats.

The machine (Fig. 717) is arranged for boring one hole at a time, and is suitable for blind, sash, door stiles, wagon-work, etc. The arbor is raised or lowered by screws *a a*, and brought forward to the work by means of the lever *b*. It is provided with space-rack clamps *c c* for holding the stuff, which will gage the holes any desired distance apart, and which avoids the necessity of setting out. The tight and loose pulleys are 6½ inches in diameter, 3 inch face, and should make 625 revolutions per minute, which will give 2,500 to the bit. *e* is the belt which conveys motion to the arbor.

In the machine (Fig. 718) the bit-arbor *a* is vertical, is driven by the belt *e*, and the stuff lies on the rest. It has a pawl and ratchet arrangement for feed, dispensing with the necessity for laying out the holes. The bit is drawn down by the treadle *c*.

Blind-stile Ma-chine'. (*Carpentry.*) Machines which get out the stuff are but saws and planers; but, when the material is brought to shape, machines are adapted for boring the holes for the slats, or making the mortises by means of piercing,—that is, by a hollow chisel of the shape of the slat-section,—or making them by a chisel repeatedly reciprocated while the stuff is fed along, as in the ordinary mortising-machine. Some of the machines space as well as bore or mortise; that is, feed the stuff along the distance between slats after each stroke.

Fig. 717.

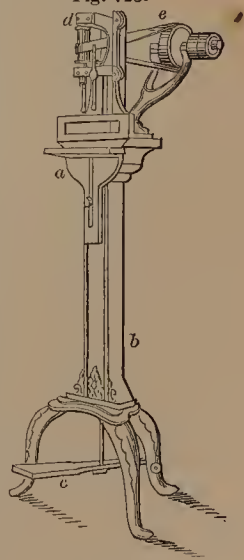


Blind-Stile Boring-Machine.

Blind-tool'ing. (*Bookbinding.*) The ornamental impressions of heated tools upon leather without the interposition of gold-leaf.

Blind-weav'ing Loom. (*Weaving.*) A loom which has its warps far apart, and an automatic device for placing within the shed the thin wooden slips which form the

Fig. 718.

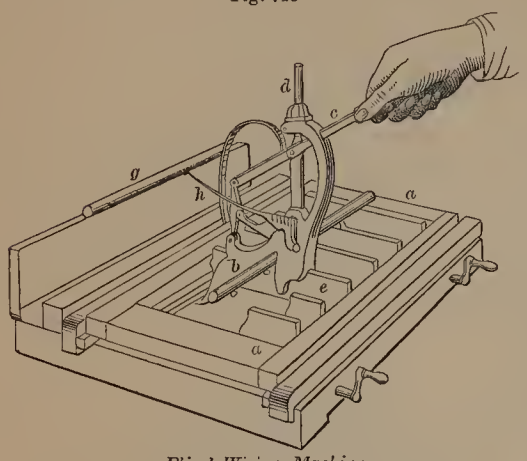


Blind-Stile Boring-Machine.

filling or woof. As the shed is opened, a rod with a gripper on the end is passed through the shed, catches a slip, and draws it between the warps, leaving it there. This is repeated between each movement of the harness.

Blind-wir'ing Ma-chine'. (*Carpentry.*) A machine for the insertion of the staples which connect the rod to the blind. The blind-frame *a* is held by adjustable slides, and the rod *b*, with its staples or rings already inserted, is laid along upon the slats

Fig. 719.

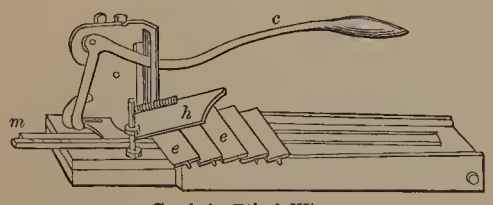


Blind-Wiring Machine.

e, the rings presented sideways. The staples to be driven straddle the wire *h* and feed down it, being driven one at a time by the lever *e* and plunger *d*, so that one leg of the staple passes through the eye on the rod *b*, and both of them enter the slat *c*. The frame is fed forward the distance between the slats after each operation.

Fig. 720 shows a somewhat similar form of machine in which the staples feed down the incline *h*, and are driven into the slats *e* as the lever *c* is de-

Fig. 720.



Crosby's Blind-Wirer.

pressed. The lifting of the lever moves forward the blind-frame by means of a pawl which engages the rack *m*.

Blink'er. (*Saddlery.*) A blind.

Blis'ter-steel. Steel formed by roasting bar-iron in contact with carbon in a cementing furnace. It is so called from its blistered appearance. To improve the quality, it is subjected to two subsequent processes, which convert it into *shear*-steel and *cast*-steel.

Block. A grooved pulley, rotating on a pintle, and mounted in a casing called a *shell*, which is furnished with a hook, eye, or strap by which it may be attached to an object. It is used for changing the direction of motion of ropes used in transmitting power, and, by compounding two or more such sheaves, to increase the mechanical power of ropes, whose rate of motion is decreased in an equivalent degree thereby.

The parts of a block are : —

The *shell*, pulley-frame, or body of the block is made of a tough wood, or sometimes of iron ; it has one or two grooves, called *scores*, cut on each end to retain the *strap* which goes around it. The shell is hollow inside to receive the *sheave* or *sheaves*, and has a hole through its center to receive the sheave-pin, called the *pintle ;* this is lined with bronze or gun-metal, called a *bouching* or *bushing*. When the shell is made of one piece, it is called a *mortise-block ;* when more than one are employed, it is termed a *made block*. The side plates of the shell are *cheeks*.

The *sheave* or wheel is of lignum-vitæ or iron, and has a peripheral groove for the rope, called the *gorge*. It has a bushing, called a *coak*, around the pintle-hole. The space between the sheave and its block, through which the rope runs, is called the *swallow* or *channel*. It answers to the *throat* of some other machines ; the *pass* in a rolling-mill.

The pin or *pintle* is the axis or axle, and is usually of iron, passing through the *bushing* of the *shell* and the *coak* of the *sheave*.

The *strap*, *strop*, *iron-binding*, *grommet*, or *cringle*, is a loop of iron or rope, encircling the block, and affords the means of fastening it in its place. The *hook* of iron-strapped blocks is frequently made to work in a swivel, so that the several parts of the rope forming the tackle may not become "foul" or twisted around each other.

For strapping with rope in the common way, the rope is cut 1½ times the circumference of the block, and stretched ; it is then *wormed*, by winding-in spun-yarn or marline between the intervals of the strands ; *parceled*, which operation consists in winding a canvas strip around the above ; and then *served* or closely wound around with marline, until just sufficient is left at each end for splicing ; it is then spliced with a short splice, the fag-ends of the strands cut off, and served over the splice.

In many cases blocks are strapped with eyes or thimbles in the ends, or, instead of the loop, have a tail, as is the case with *jigger blocks ;* in this case they are called *tail-blocks*.

The *purchase*-block is double-strapped, having two scores in the shell for the purpose ; the rope is *wormed*, *parceled*, and *served*, or may be *wormed* and *parceled* only, and *spliced*. It is then doubled up so as to bring the splice at the bottom of the block. The seizing is put on the usual way, except it is crossed both ways through the double parts of the strap. The straps of these blocks are so large and stiff that a purchase should be employed to set them securely in the scores of the blocks, and bring them into their proper place.

Blocks receive names from peculiarities of structure, from their materials, uses, arrangement in the tackle, mode of connecting them to objects, etc. See under the following heads . —

Bee-block.
Block and tackle.
Buckler.
Bull's-eye.
Cat-block.
Cheek-block.
Clew-garnet block.
D-block.
Dead-eye.
Differential-block.
Double-block.
Euphroe.
Fall-block.
Fiddle-block.
Fish-block.
Fly-block.
Gin-block.
Heart-block.
Hook-block.
Iron-block.
Jack-block.
Jewel-block.
Long-tackle block.
Monkey-block.
Muffle-block.
Ninepin-block.
Pulley-block.
Purchase-block.
Quarter-block.
Ram-block.

Rouse-about block.	Strap-block.
Running-block.	Tack-block.
Sheave.	Tackle-block.
Shell.	Tail-block.
Shoe-block.	Thick-and-thin block.
Shoulder-block.	Top-block.
Single-block.	Treble-block.
Sister-block.	Tye-block.
Smeaton's block.	Uvrow.
Snatch-block.	Viol-block.
Spring-block.	Waist-block.
Standing-block.	Warping-block.

The pulley-block, with two or more sheaves, was well known to the Romans. A block with three sheaves was called *trispastos*. Tackle with two sheaves in the lower block and three in the upper one was called *pentaspastos*. The tackles were variously arranged, much as at the present day, and the derrick spars and masts were secured by guys.

A large number of obelisks were removed from Egypt to Rome, Constantinople, and Arles, and gave employment to complex and powerful tackle.

Blocks do uot appear to have been known in ancient Egypt; the ropes were rove through rings.

2. (*Carpentry.*) A square piece of wood fitted in the reëntering angle formed by the meeting edges of two pieces of board. The blocks are glued at the rear and strengthen the joint.

3. (*Hat-making.*) A cylinder of wood over which a hat or bonnet is shaped in the process of manufacture.

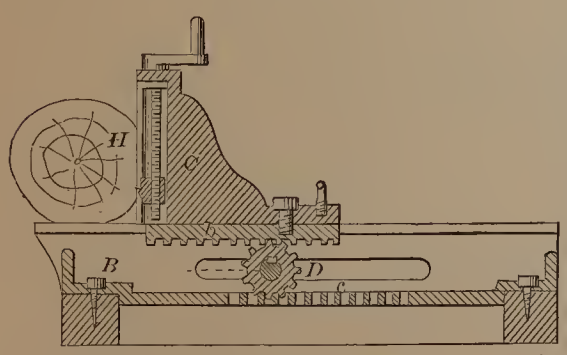
4. (*Saddlery.*) A former or block on which a piece of wet leather is molded by hammering or pressing.

5. (*Ordnance*, etc.) In the ordnance service the term *block* is applied to two different articles, which have very different fuuctions; one kind being short pieces of scantling, used for elevating cannon and supporting them in position a short distance from the ground, or in assisting in their transfer from higher to lower levels, and *vice versa*. These are designated as whole, half, and quarter blocks, and have a uniform length of 20 and width of 8 inches, their respective thickness being 8, 4, and 2 inches.

Gin-blocks are the pulleys through which the fall of a gin is rove, and are known as single, double, or treble blocks, according as they have one, two, or three sheaves; the sheave is of brass and the shell of wrought-iron.

The varieties of blocks are more fully described uuder the heads enumerated in the list above.

Fig 721.



Head-Block to Saw-Mills.

8. (*Saw-mill.*) One of the frames on which an end of a log rests in a saw-mill. The log is usually set over towards the saw the thickness of one board, plus the kerf, between the cuts. In the more modern and improved form the *head* and *tail* blocks are set simultaneously. In the circular saw-mill the knees resting on the head and tail blocks are moved, pushing the log *H* on the blocks *B*, as in Fig. 721, where the knee *C* is operated by a spur pinion *D* and racks *b c*. See also CIRCULAR SAW; HEAD-BLOCK.

Block and Tack'le. A term including the block and the rope rove through it, for hoisting or obtaining a purchase. See TACKLE.

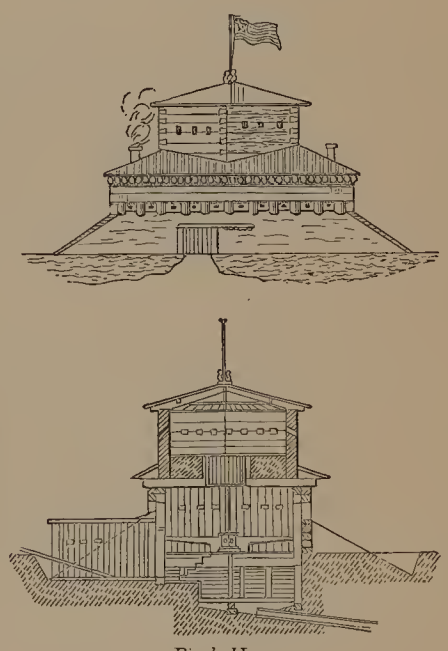
Block-book. (*Printing.*) A book whose pages are impressions from engraved blocks, each of which formed a page. This was a very old Oriental invention, and did not differ especially from the calico-printing of China, India, Arabia, and Egypt, the books and placards of China, and the printed playing-cards commonly used in Europe many years before Coster, Guttenberg, and Faust.

The great invention was *movable* types. See PRINTING.

Block-fur'nace. (*Metallurgy.*) A *blomary*.

Block-house. (*Fortification.*) A structure of heavy timber or logs for military defence, having its sides loopholed for musketry. When of large size, it may be provided with ports or embrasures for artillery. The plan may be square, rectangular, or polygonal. If it is desired to obtain flanking arrangements, the house may be made in the form of a cross. When more than one story high, the upper one is sometimes made to project over the lower, so as to obtain a direct downward fire. A ditch is dug around the block-house, the earth from which is thrown up around the lower part of the house; the roof may also be covered with earth.

Fig. 722.



Block-House.

Block-in-course Ma'son-ry. (*Masonry.*) A kind which differs from ashlar masonry chiefly in being built of smaller stones. The usual depth of a course is from seven to nine inches.

Block'ing. 1. (*Leather.*) The process of bending leather for boot-fronts to the required shape. See CRIMPING.

2. (*Bookbinding.*) Impressing a pattern on a

book-cover by a plate or association of tools under pressure. It is called *blind* or gold blocking. In the latter case, gold-leaf is used; in the former, the bare block.

Fig. 723.

Blocking.

3. (*Carpentry.*) A mode of securing together the vertical angles of wood-work. *Blocks* of wood are glued in the inside angle.

Block'ing-course. (*Architecture.*) The upper course of stones or brick above a cornice or on the top of a wall.

Block'ing-down. (*Sheet-metal Working.*) Sheet-metal is *blocked down* upon a mold or shape by laying above it a thick piece of lead, which latter is struck by the mallet or hammer. This mode is sometimes adopted to bring a plate partially to shape before swaging it between the dies.

Block'ing-ket'tle. (*Hat-making.*) A hot bath in which hats are softened in the process of manufacture, so as to be drawn over *blocks*.

Block'ing-press. A bookbinder's screw-press in which blocking is performed. It has less power than the embossing-press, which operates with large dies, being used for ornamentation, requiring but a comparatively small pressure.

The die is adjusted in the upper bed (or plate), and is heated by means of gas-jets coming down through a cavity at its back. The book-covers are introduced *seriatim* upon the lower bed by the operator, who by a turn of the handle brings the upper bed down with a gentle and equable pressure, fixing the gold-leaf, when this is employed, upon the surface, previously prepared for the purpose. A boy, who assists, removes the superfluous portions with a rag, which becomes thoroughly saturated with the precious metal in the course of use, and is sold to the refiners.

Block-let'ter. (*Printing.*) Type of large size cut out of wooden blocks.

Block-let'ter Cut'ting-ma-chine'. Block-letters, or wooden type, are generally made of cherry, cut endwise. They are made of sizes from 2 or 3 line Pica up to 150-line Pica, more than two feet in length.

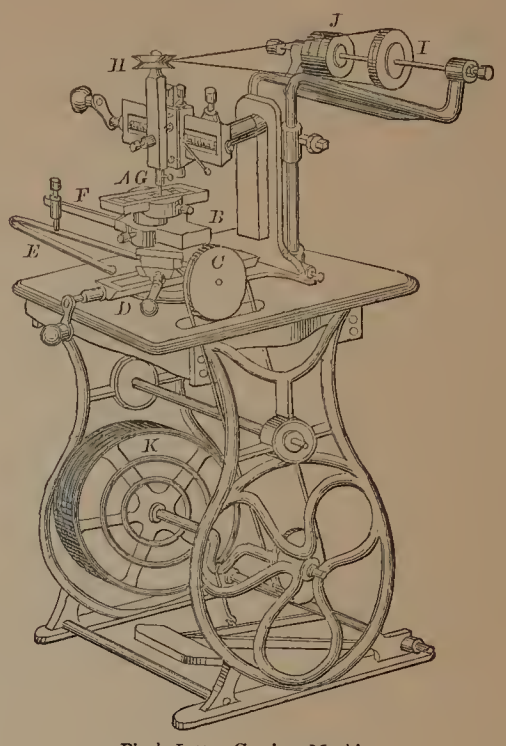
Fig. 724 illustrates a machine for cutting these types. The wood, having been carefully planed to a true surface and even thickness, is cut into blocks of suitable size, and the outlines of the letters formed as a guide in cutting. A block is placed in the chuck *A*, fixed in the slide *B*, which may be moved back and forth in a guide, and to which a rotary motion may also be imparted by means of a gear-wheel and screw operated from the pulley *C*.

Below this is another slide *D*, carrying an arm *E*, which supports an upright bar, with a rod *F* attached to the chuck *A*. Below all is a circular plate pivoted to the table, and capable of being turned in any desired position and secured there, for adjusting the work to the proper angle previous to cutting.

The cutter *G* is fixed in a spindle which is rotated by the pulleys *H I*, the latter on a shaft driven by either of the fast-pulleys at *J*, operated by a band-wheel *K* on the treadle-shaft. The box carrying the cutter-spindle has vertical adjustment for varying the depth of cut, and may also be moved laterally by a screw and crank. A lever is provided for lifting the cutter clear of the work.

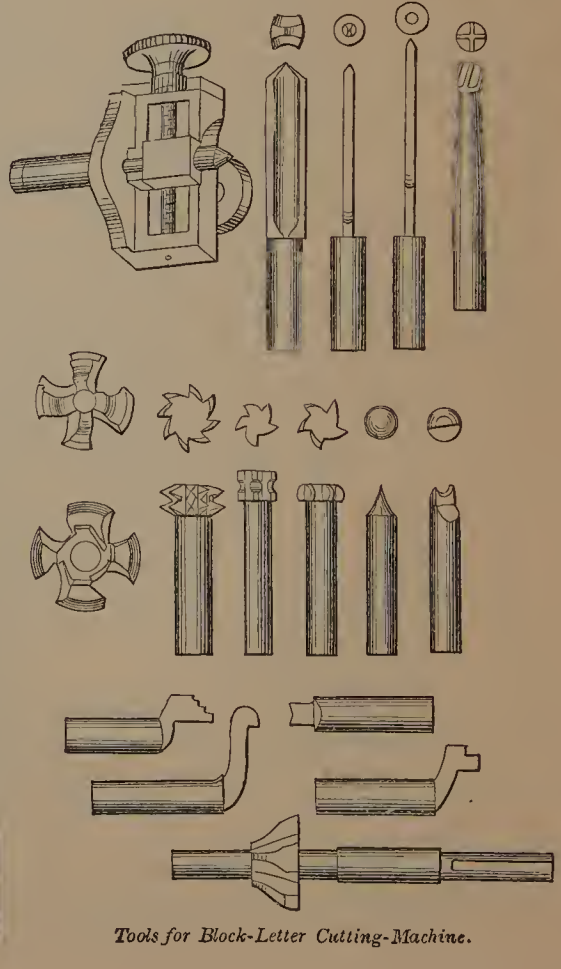
By means of the bar and rod *E*, *F*, and pulley *C*, and their connections with the slide *B* and chuck *A*, in conjunction with the slide *D*, the work may be moved in any direction, causing the cutter to produce any combination of right lines or curves.

Fig 724.



Block-Letter Cutting-Machine.

Fig. 725.



Tools for Block-Letter Cutting-Machine.

Fig. 725 shows various forms of cutters, some of which are designed for making any number of circles of uniform diameter, and others for clearing out the wood from those parts not designed to show in printing.

Block-mak'ing Ma-chine'. The first set of machinery for making blocks for tackle was the invention of the elder Brunel, and was constructed by Maudslay. The invention of "the ingenious American mechanic," as Mr. Tomlinson calls him, was endorsed by General Bentham, the Inspector-General of Naval Works, and sanctioned by the Lords of the Admiralty in a remarkably short space of time, — one year. The work on the machinery was commenced in 1802, and was finished in 1808. The machines were set up in Portsmouth Dock-yard, and a duplicate set was made for Chatham Dock-yard, to be used in case of accident, but has not been needed. For twenty-five years the machines required no essential repairs. The cost was $230,000, and the saving per annum over hand labor is variously estimated from $83,000 to $150,000. Brunel received $5 per day for superintendence, $5,000 for the working models, and a grant of $83,000 when completed.

The machines are in three different sets, fifteen in a set, for making different sizes; each set having a certain range of adjustability as to the sizes of blocks turned out.

The different blocks made by these machines are as follows: —

Thick block, with 1, 2, 3, or 4 sheaves, and from 4 to 28 inches in length	72	sizes.
Thin blocks, 6 to 26 inches	48	"
Clew-garnet and clew-line blocks	10	"
Sister-blocks	20	"
Topsail-sheet blocks	20	"
Fiddle or viol blocks	24	"
Jack-blocks	20	"
	214	sizes.

The first set makes blocks 4 to 7 inches in length, with wooden pins, at the rate of 700 per day.

The second set makes blocks 8 to 10 inches in length, with iron pins, at the rate of 520 per day.

The third set makes blocks 11 to 18 inches in length, at the rate of 200 per day. Total, 1,420 per day.

Two machines are employed for making dead-eyes from 5 to 9 inches, and from 10 to 19 inches in diameter.

One large boring-machine, not included in the above.

Two machines for making the iron pins.

Total, 50 machines.

These machines are driven by a steam-engine of 32-horse power.

With these machines 4 men do the work of 50 in making shells, and 6 men do the work of 60 in making sheaves; total, 10 men doing the work of 110 previously working by hand. The amount actually supplied was about 135,000 blocks per annum from 1808 to 1816. 1,500 blocks are required in rigging a ship of the line, besides dead-eyes, say 160.

The sawing-machines are employed on one side of the house to cut the elm and ash timbers into parallelopipedons of the required sizes and shapes; and the block-making machines on the other side are employed to reduce these blocks to shape, fashioning the outside and the mortise, and to make and *coak* the sheaves.

The machines are as follows: —

1. The *reciprocating cross-cut saw*, which is used on large timber to cut into lengths timber of large size.

2. A *circular cross-cut saw*, for operating on timbers of smaller diameter.

3. The *reciprocating ripping-saw*, for cutting the *jugglcs*, or cylindrical blocks of timber, into parallelopipedons of the required proportions.

4. The *circular ripping-saw*, for performing the same operation on small timber.

5. The *boring-machine*, for boring a hole through the shell to start the mortise, and boring the hole for the pintle. See BORING-MACHINE.

6. The *mortising-machine*, which completes the hollowing out of the shell, making the full opening for the sheaves. See MORTISING-MACHINE.

7. The *corner-saw*, to bring the shell to an approximate shape, ready for the next machine. See CORNER-SAW.

8. The *shaping-machine*, which turns the outside of the shell to form. See SHAPING-MACHINE.

9. The *scoring-machine*, which cuts the scores on the shell for the reception of the straps by which it is slung. See SCORING-MACHINE.

This completes the dressing of the *shells* of the blocks, except some smoothing where the wood is roughed up in dressing.

10. For making the sheaves three kinds of saws are employed. A *reciprocating saw* is used for making disks of wood by cross-cutting lignum-vitæ logs. A *circular saw* is used for cross-cutting smaller logs. A *crown-saw* and center-bit are used for rounding the sheaves and boring the center-hole.

11. The *coaking-machine* cuts three semicircular cavities at equal distances around the hole made by the bit. This cavity is for the reception of the coak or bush of bell-metal, which forms a socket for the center-pin.

12. A *drilling-machine*, for perforating the three semicircular projections of the coak for the reception of short wire pins or rivets, by which the coak is attached to the sheave.

13. A *riveting-machine;* two small tilt-hammers for riveting the wires which hold the coaks in their places.

14. A *broaching-engine*, which reams out the center-hole.

15. A facing-lathe turns the flat sides of the sheaves and makes the groove in the periphery.

The iron center-pins are turned in a lathe, and then polished by being fixed in a vertical revolving axle, and forced down into a die immersed in oil, and hold three pieces of hard steel, between which the pin is pressed as it turns, and becomes completely polished.

Block-print'ing. A mode of printing cotton cloth or paper for hangings, in which the pattern is engraved in relief upon a block, which is dabbed upon the color and impressed by hand upon the material, which lies upon a table before the workman. When the pattern is in several colors, different blocks of the same size are employed, the raised pattern in each being adapted for its special portion of the design. The exact correspondence of each part, as to position, is secured by pins on the blocks, which pierce small holes in the material and indicate the exact position. This is a registering system similar to that adopted in chromatic printing, and in all forms of lithographic printing in which more than one color is used.

This mode of printing was nearly superseded by the system of Perrot, in which the calico passed between a square prism and three engraved blocks, which were brought in apposition to three faces of the prism, and delivered their separate impressions thereupon in succession. Each block was inked after each impression, and the cloth was drawn

through by a winding cylinder. The blocks were pressed against the cloth by springs. This was a great improvement upon block-printing, being nearly twenty times as rapid; but the cylinder or roller printing has outstripped them both, performing as much labor as 100 block-printers. See CALICO-PRINTING.

Block-teeth. (*Dental.*) Two or more teeth made in a block carved by hand from ivory, whale's or walrus's teeth, etc.

Block-tin. Tin cast into ingots.

Blom'a-ry. (*Metallurgy.*) The first forge through which iron is passed. The pig-iron, having been puddled and balled, is brought to the hammer or squeezer, which makes it into a *bloom*. *Bloomary.*

Blond-lace. A silk lace of two threads twisted and formed in hexagonal meshes.

Bloom. 1. (*Metallurgy.*) A loop or ball of puddled iron deprived of its dross by shingling or squeezing.

2. (*Leather Manufacture.*) A yellowish powdery coating on the surface of well-tanned leather, by which its quality is adjudged. It may arise from a deposit of surplus tannin, and thus be an indication that the process is fully accomplished. Oak-bark tanning yields the best *bloom*, and some of the quick processes none at all.

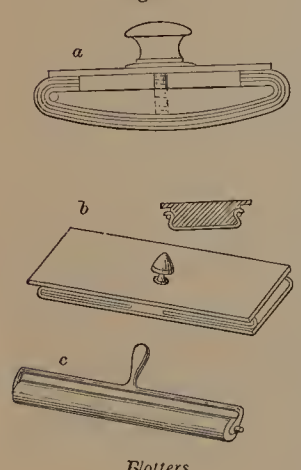
Bloom'er-pit. A tan-pit in which hides are subjected to the action of *strong* ooze. So called because the conclusion of the process brings a *bloom* on the skin. Also called a *layer*.

The pits containing a weaker solution are called *handlers*.

Bloom-hook. (*Metallurgy.*) A tool for handling the heated bloom, drawing it towards the shingler, moving it under the hammer, etc. *Bloom-tongs.*

Blot'ter. A device for absorbing the superfluous ink from paper after writing. The blotter may be merely a thin book interleaved with bibulous paper, or a pad or cushion covered with blotting-paper, *a* or *b*, and having a handle, being used after the manner of a stamp. Another form consists of a roller *c* covered with successive layers of blotting-paper, and revolving on an axis, a handle being attached for convenient use. The layers of paper may be removed as they become soiled, and fresh paper substituted.

Fig. 726.



Blotters.

Blot'ting-pad. A few sheets of blotting-paper on the writing-table or desk, to form a soft bed for the writing-paper.

Blot'ting-pa'per. A thick, bibulous, unsized paper, used as a pad on the desk or to imbibe superfluous ink from undried manuscripts.

Blow'er. A machine for creating an artificial current of air by pressure. A *plenum* engine, as contradistinguished from a *vacuum* engine, such as an *aspirator*.

1. Blowers are used to increase drafts in furnaces; to furnish vital air to close and fetid places, as mines, wells, cisterns, holds of ships, etc.; to furnish a current of warmed, cooled, moistened, or medicated air to public buildings or others which are liable to be closely occupied; to furnish a drying atmosphere in lumber, grain, or meal kilns, powder-mills, etc.; to assist in evaporating fluids by removing the steam from the vicinity of the boiling syrup or other solution; to raise fluids on the principle of the Giffard injector, as in some of the ejectors used in deep oil-wells; to assist in the dispersion of liquids, as in atomizers, and some ice-making machines.

The fan-blower is believed to have been invented by Teral, 1729. The water-bellows by Hornblower.

Blowing-machines were erected by Smeaton at the Carron Iron Works, 1760.

The hot-air blast was invented by James Neilson, of Glasgow, and patented in 1828.

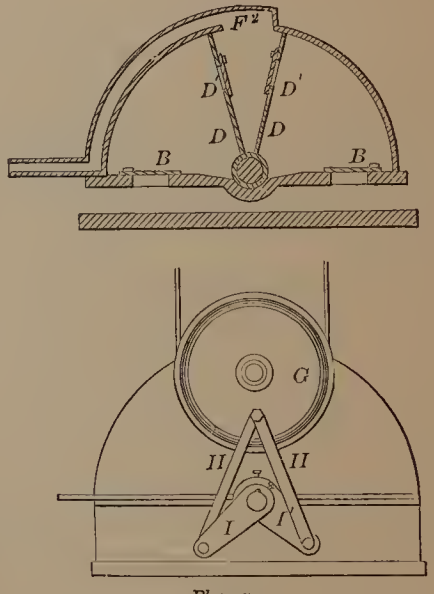
Wooden bellows, in which one open-ended box is made to slip within another, with valves for the induction and eduction of air, were used at Nuremberg, 1550. They were used in the next century for smelting, blacksmithing, and for organs. Such a machine is in principle the same as Fig. 106, and the converse of that shown in Fig. 114.

P. Fannenschmid of Thuringia appears to have made, about 1621, a much more effective blower than was previously used by the metallurgists of his section. This was a flat vane reciprocating in a sector-shaped box and having an inlet valve for the air. At the hinging-point of the vane, the edge of the sector, an eduction pipe proceeds from the box. Slips of wood on the edge of the vane were pressed against the sides of the box, to prevent the leakage of air.

Somewhat similar to this is the oscillating or pulsating piston (Fig. 727).

The fans *D D'* are oscillated in a semi-cylindrical case with an upper exit at F^2, and two valves *B B* opening upwardly; the fans have also valves opening towards each other. The alternate oscillating motion of the fans is produced by crank connection *H I* with a driven pulley *G*.

Fig. 727.

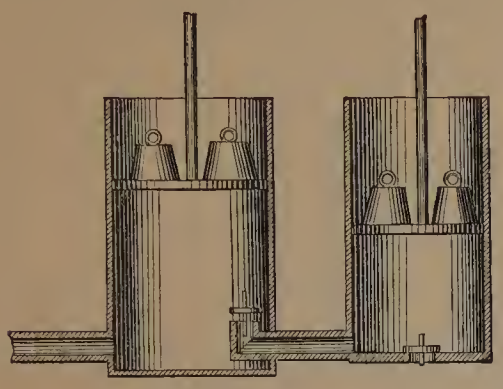


Blower.

The earlier modern forms of machine-blowers consist of cylinders with pistons, the differences between them consisting principally in the means for communicating motion and for securing a uniform blast; an arrangement for this purpose is shown in the figure, consisting of two connected cylinders, one of them provided with a discharge-pipe; by the descent of

the piston in the first cylinder the air is forced into the other cylinder through a valve which rises to allow its passage. At the same time the piston of the second cylinder is caused to rise, and, on reach-

Fig. 728.

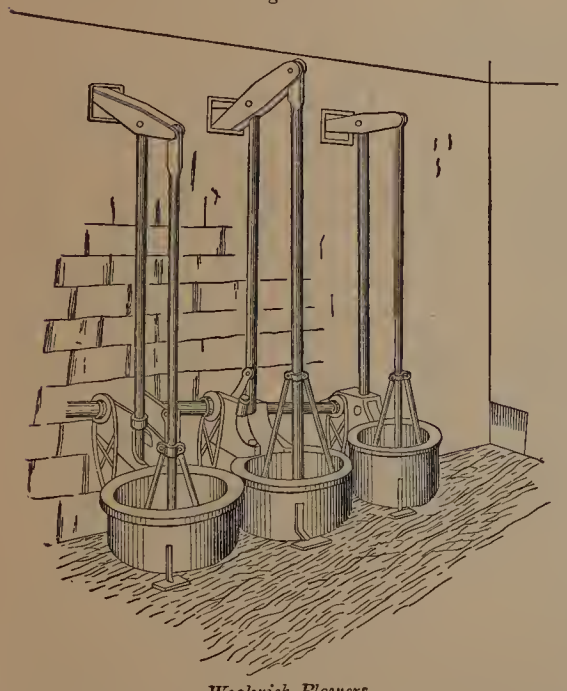


Piston-Blower.

ing its highest point, commences its descending motion, closing the communicating valve and forcing the air through the discharge-pipe, while the first piston rises, filling its cylinder with air, to be similarly forced into the second cylinder, and thence expelled as before.

In other forms of blowing apparatus on this principle, the air is forced from the blowing cylinders into a reservoir, whence it issues by the force of its compression. Such is that used at Woolwich, England (shown in Fig. 729). The beams of the pistons

Fig. 729.



Woolwich Blowers.

are so connected that when one is at the top of the stroke another is midway of its cylinder and the third at its lowest point, maintaining very nearly uniform pressure in a wind-chest below with which each cylinder communicates.

Blowers on the fan principle are the favorite subjects of the exercise of the ingenuity of modern inventors in this line.

In these the air is admitted through an aperture at or near the axis of the rotating fan, whence it is driven toward the periphery by means of curved arms, and discharged through an opening in the case.

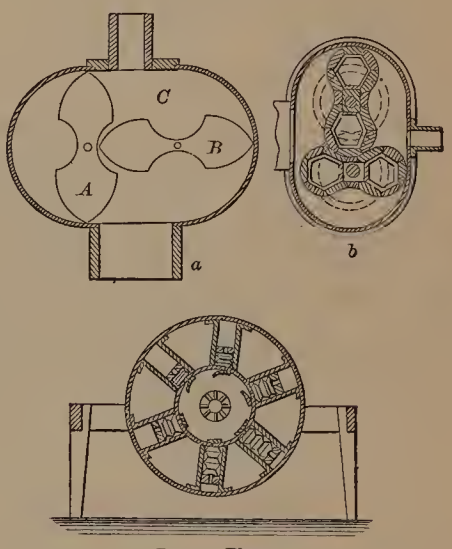
In Schiele's compound blowing-fan, two fans are combined on the same shaft, so as to act successively on the same air. By the first the air is driven into a chamber between the fans, at a pressure of perhaps six ounces. The second receives the air at this pressure and compresses it as much more, so that it is delivered at length into the furnace at a pressure of twelve ounces per square inch.

Lloyd's noiseless fan consists of a drum formed on two flat hollow cones of thin metal, brought near together by their bases, and connected by a series of curved partitions extending from the center to the circumference. The cones are open about the vertexes, and an axis of revolution supports the whole by being the common origin of all the curved partitions. This drum rotates within a closed box, and discharges the air received at the center through a tangential outlet. See FAN.

Other rotary blowers are on the principle of the rotary pump or rotary engine, having two portions which revolve in apposition.

In Fig. 730, *a* represents a blowing-machine having two similarly shaped elongated cams *A B*, the projections of each of which fit into the depressions of the other. These are arranged in a suitably shaped box *C*, and driven by pitmen so arranged that por-

Fig. 730.



Rotary Blowers.

tions of the periphery of each blower shall be constantly in close proximity, while the two ends or wings of each move in proximity to the curved sides of the box. The rotation of the two blowers in opposite directions draws the air through an opening in one side of the box, and forcibly discharges it through a blast-pipe at the other.

Root's blower, *b*, is similar in principle to the foregoing; the projections of the cams are, however, rounded off so as to form circular arcs, while the depth of the depressions is decreased, causing a longer lap on the abutting surfaces, so as to provide against the escape of air in the wrong direction.

In *c* a series of bellows, provided with suitable valves, are radially arranged around a tube surrounding the axis of a wheel. A heavy block moving in guides descends by gravity on approaching a vertical position, admitting air during the lower part

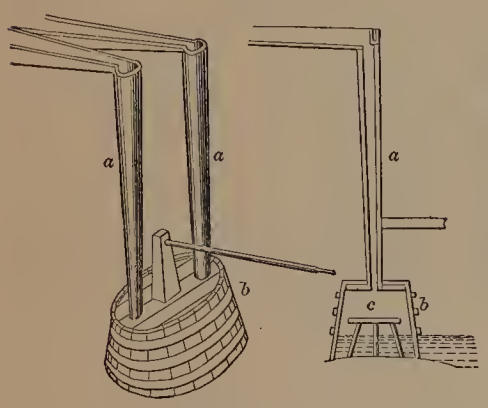
and forcing it out through the central tube during the upper part of the revolution.

Blowers have been made having an eccentric drum, with radial pistons or valves, which rotates within an exterior casing; or the interior of the case may be itself eccentric and the drum central on its shaft,—the pistons, in either case, being reciprocated alternately back and forth in slots in the drum, as that portion of its periphery in which they are situated approaches or recedes from the side of the casing.

The principle of the rotary pump is entirely applicable to the blower, and a machine of this kind which causes a current of water to ascend may be made to create a blast of air.

The *hydrostatic bellows* is formed by a body of water falling through a pipe or pipes *a a*, pierced with

Fig. 731.

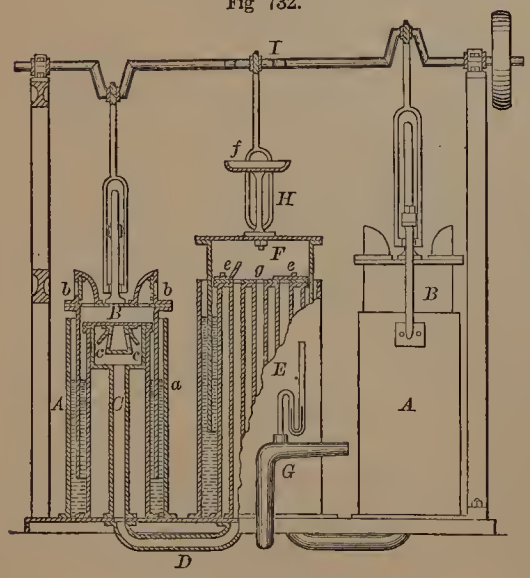


Hydrostatic Bellows.

a number of holes inclined inwardly and downwardly. The current of water draws air in at these orifices, and carries it down into the chamber *b* below, where it is compressed, and, separating from the water, rises into a trunk on the upper part of the chamber, whence it is conducted by a pipe to the forge. The water dashes upon a table *c* in the chamber, which assists in the separation of the air, and then escapes by a trap beneath the water-level. The force of the blast is proportionate to the volume and fall of the water, and is regulated by a sluice.

Thirion's hydraulic pressure-blower is termed by

Fig 732.

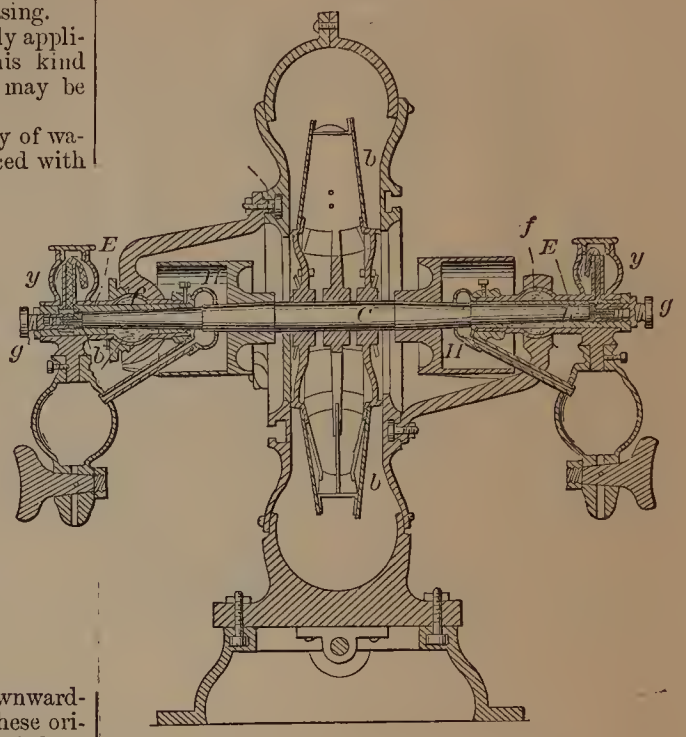


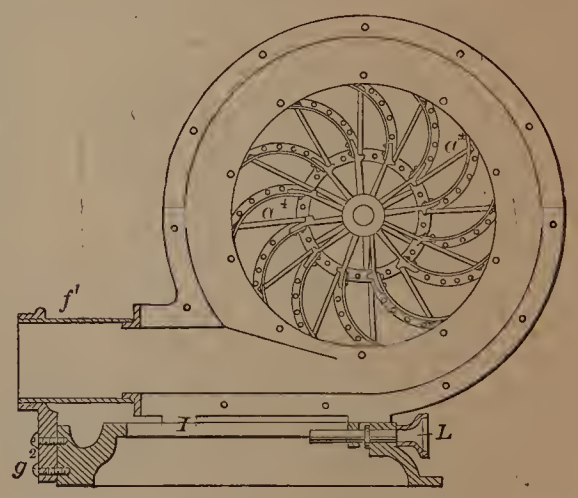
Thirion's Hydraulic Pressure-Blower.

him *machine soufflante à colonne d'eau.* The water is, however, merely employed to pack the working parts and prevent friction.

A A are two compressing cylinders having inner and outer walls, the space between which is filled with water up to a certain level, as *a*. *B B* are cylinders which are reciprocated within this annular

Fig. 733.





Sturtevant's Blower.

space by a driven pulley and cranked shaft *I*. The regulator comprises an annular outer cylinder *E* and an interior cylinder *F*. The outer cylinder is partially filled with water, and the inner has a vertical motion therein, limited by the guide *H* rigidly suspended from the shaft *I*.

The upward movement of either cylinder *B* admits air through the valves *b*, which is forced by the downward movement through the valves *c c* in the enlarged portion of the pipe *C D*, into the upper cylinder *F* of the regulator, through the valves *e e*. The weight of the cylinder *F* forces the air into the central tube *g*, which forms the upper part of the

blast-pipe *G*, under an amount of pressure regulated by weights in the scale-pan *f* fixed on the top of the guide-rod of the cylinder.

Sturtevant's blower has spoked wheels, having conical annular disks mounted on an axis driven by two belts to prevent tendency to wabbling. The air enters between the spokes around the axis, and is driven forcibly by the curved floats which span the space between the annular disks, being discharged into the peripheral receiving-chamber *A*, whence it reaches the horizontal eduction-pipe shown in the lower part of the figure. Within each of the band-pulleys is an oil-collector *H*, which intercepts superfluous oil and conducts it to the oil-chamber *l*, whence it may be drawn by a faucet. The shaft *C* is supported in tubular bearings at *E E*, sustained in brackets by means of ball-joints *f*, whereby the bearings are able to accommodate themselves to the shaft while in revolution. The oilers *y* for the journal of the shaft *C* are near the end, and have dripping wicks which feed the lubricant in regular quantity; the oil-collectors *H* intercepting any superfluity, as already stated. The set screws *g g'* afford means for adjusting the shaft *C* lengthwise, so as to bring the wheel to its proper position in the case.

Another form of blower, if the term be admissible, is a steam-jet, which induces a current by producing a partial vacuum. It is used in providing the vacuum in front of the traveling-carriage of a pneumatic tube, a jet of steam issuing from an annular nozzle concentric with that end of the tube toward which the carriage is moving. The steam or vapor carries along with it a current of air which is drawn from the tube. It is more correct to call this a substitute for the *blower*.

The steam-jet for the ventilation of mines was used long ago, and then abandoned. It has since been tried very successfully at a colliery at Oldham, England, in which the satisfactory flow of nearly 23,000 cubic feet of air per minute was obtained.

2. An iron plate temporarily placed in front of an open fire, to urge the combustion.

3. A machine for separating the hair from the fur fibers. See BLOWING-MACHINE.

Blow'er and Spread'er. (*Cotton-Manufacture.*) A machine for spreading cotton into a lap, the action of beaters and blower being conjoined for the purpose. See COTTON-CLEANING MACHINE.

Blow-gun. Used by the Barbados Indians of Brazil and other aborigines of South America. A similar contrivance is employed by some of the Malays, by whom it is called "sumpitan." The arrows are about fifty inches long, made of a yellow reed and tipped with hard wood, which has a spike of cocourite wood poisoned. The spike is cut half through, so as to break off in the wound, that the arrow-shaft may drop and be recovered. See AIR-GUN.

Blow'ing-cyl'in-der. (*Pneumatics.*) A form of *blowing-engine*.

Smeaton introduced the blowing-cylinders at the Carron iron-works, and by the power and volume of blast made effective the earnest and repeated attempts of the English to smelt iron by the use of the coke of pit-coal. This was in 1760, and utilized the invention of Abraham Darby, of Colebrookdale, in 1735.

Blow'ing-en'gine. Properly, one applied to the duty of driving a blower; sometimes it is intended to mean a machine by which an artificial draft by *plenum* is obtained. For such, see BLOWER.

Blow'ing-fur'nace. (*Glass-making.*) A furnace in which articles of glass in process of manufacture are held to soften, when they have lost their plasticity by cooling.

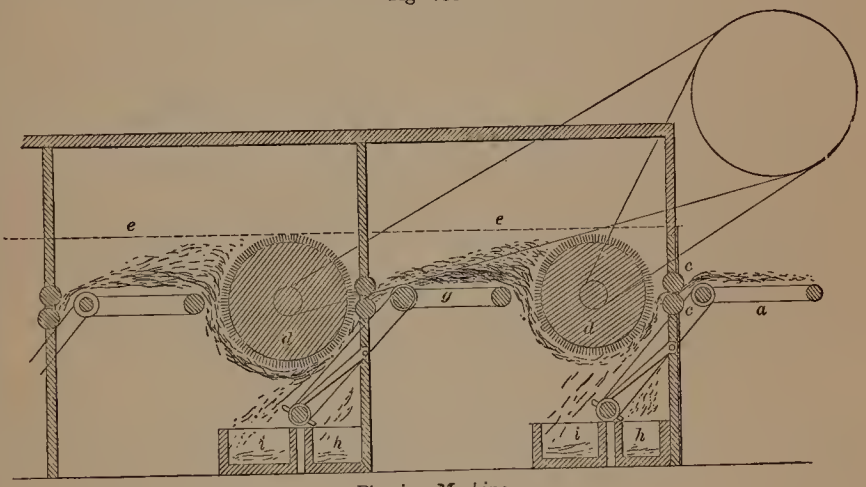
Blow'ing-pipe. (*Glass-making.*) The glass-blower's pipe; *bunting-iron*; a *pontil*.

Blow'ing-ma-chine'. 1. One for creating an artificial draft by forcing air. See BLOWER.

2. (*Hat-making.*) A machine for separating the "kemps" or hairs from the fur fibers. The fibers are fed from an endless apron between rolls to a revolving picker in a closed chamber, which tosses the mass upwards against a horizontal gauze partition, through which the air escapes, whence they fall on to a second apron, which carries them to a second chamber, where this operation is repeated. The coarse and heavier hairs fall by their gravity into boxes in the bottom of the chamber. The operation twice or thrice repeated completes the separation, when the fur is ready for the forming-machine which makes the bat for felting.

Fig. 734 represents the ordinary fur blowing-machine.

Fig. 734.



Blowing-Machine.

The mixed fur and hair is placed on the endless apron *a*, and is fed into the rollers *c c*, which feed the rotating-picker *d*. This separates it, and tosses the mass up toward the wire-gauze screen *e*, which allows the air to escape, and causes the mass to fall on to the second endless apron *g*, which carries it into the second apartment. While the disintegrated mass of fur has thus been passing through the first apartment, the heaviest and coarsest hairs and the dust have by reason of their weight fallen into the boxes *h i*.

The mass, on passing into the second apartment, is treated in a precisely similar way, and is usually conducted from thence into a third apartment, where it is operated on in the same way, and finally delivered in a fit state for manufacture.

3. (*Cotton-Manufacture.*) A part of the batting-machine, or a machine in which cotton loosened by willowing and scutching, one or both, is subjected to

a draft of air occasioned by a fan, which removes the dust and other light small refuse from the fiber. See BATTING-MACHINE.

Blow'ing-off. (*Steam-Engine.*) The process of ejecting the super-salted water from the boiler, in order to prevent the deposition of scale or salt.

Blow'ing-pot. (*Pottery.*) A pot of colored slip for the ornamentation of pottery while in the lathe. The pot has a tube, at which the mouth of the workman is placed, and a spout like a quill, at which the slip exudes under the pressure of the breath. The ware is rotated in the lathe, while the hollows previously made in the ware to receive the slip are thus filled up. Excess of slip is removed, after a certain amount of drying, by a spatula or knife, known as a *tournasin*.

Blow'ing-through. (*Steam-Engine.*) The process of clearing the engine of air by blowing steam through the cylinder, valves, and condenser before starting.

Blow'ing-tube. (*Glass-making.*) *Ponty; Pontil.* An iron tube from four to five feet in length, and with a bore, according to the character of the work, of from one third to one inch in diameter. The *metal*, as the molten glass is called, is gathered on the larger end, which is thrust into the glass-pot, and the mouth is applied to the smaller end to blow the glass, making it hollow by a body of air; the shape of the object being determined by swinging, by rolling on the *marver*, by tongs, and other tools. See GLASS-BLOWING.

Blow-off Cock. (*Steam-Engine.*) A faucet in a steam-boiler for allowing a quantity of water to escape, to rid the boiler of mud; or, in marine engines, of a strong solution of salt.

Blow-off Pipe. (*Steam-Engine.*) A pipe at the lower part of a steam-boiler by which sediment is driven out occasionally.

Blow-o'ver. (*Glass.*) An arrangement in blowing glass bottles or jars in molds in which the surplus glass is collected in a chamber above the lip of the vessel with but a thin connecting portion, so that the surplus is readily broken off without danger to the vessel itself.

Blow-pipe. A tube through which a current of air is forced, in order to direct a flame and concentrate its heat at a particular spot.

The origin of this instrument is unknown, though it is undoubtedly of very great antiquity.

Among the earliest illustrations of metallurgic operations may be cited the little furnace with cheeks to concentrate the heat upon the crucible, and the fire urged by the blow-pipe. There seems to be a purpose to direct the flame upon the crucible in the manner of a blow-pipe, for the blast-furnace and foot-bellows were well known at that time, and are shown in the ancient paintings of Kourna, Thebes.

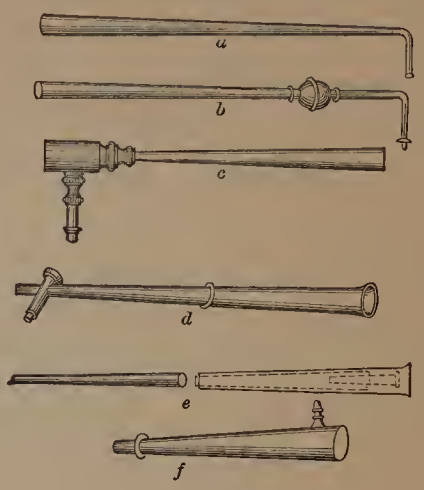
Fig. 735.

Blow-Pipe (Thebes).

The blow-pipe is used by goldsmiths, jewelers, and others, in soldering of metals, and by glass-blowers in sealing glass tubes.

It is made of various forms for special uses.

Fig. 736.



Blow-Pipes.

a. Common or simplest form of blow-pipe.

b. Two-part blow-pipe having a bulb near the small end, composed of two hemispheres in which the moisture from the breath is condensed, and which may be unscrewed for convenience of carrying in the pocket.

c. Gahn's blow-pipe made in four separable parts.

d. Woilaston's blow-pipe ready for use.

e. Wollaston's blow-pipe with its lower end and beak slid in for carriage in the pocket.

f. Dr. Black's blow-pipe. The smaller end is the mouth-piece, and the larger condenses the moisture.

While the use of the blow-pipe dates from distant antiquity, yet its use in mineralogy, in determining the nature of the metals in ores, dates from Antony von Suab in 1738, and Cronstedt, 20 years later. The subject may be satisfactorily pursued in "Plattner on the Blow-pipe," and by consulting a late work, "System of Instruction in the practical Use of the Blow-pipe."

The *reducing* flame is produced by blowing the flame of the lamp aside by a weak current of air impinging on the outer surface, the flame being unchanged except in direction. Unconsumed carbon, at a white heat, giving the yellow color to the flame, aids in the reduction of the substance.

The *oxidizing* flame is formed by blowing a strong current into the interior of the flame, perfecting the combustion. The object, being intensely heated, and exposed to the surrounding air, becomes oxidized.

In Fig. 737 is shown an apparatus charging the air-chamber by mechanical means instead of by the breath. Such devices are now much used by jewelers, mechanical dentists, and in certain departments of analytical chemistry.

It consists of a table having a chamber into which air is forced by a pump 2, operated by a treadle 5, maintaining a continuous blast through the pipe 3, to which is attached a flexible tube, enabling the flame of the lamp 4, on the table, to be thrown in any direction.

The compound or oxyhydrogen blow-pipe, invented by Dr. Robert Hare, of Philadelphia, in the early part of the present century, surpasses, in the intensity of the heat it produces, anything that had previously been attained. The flame is formed by unit-

Fig. 737.

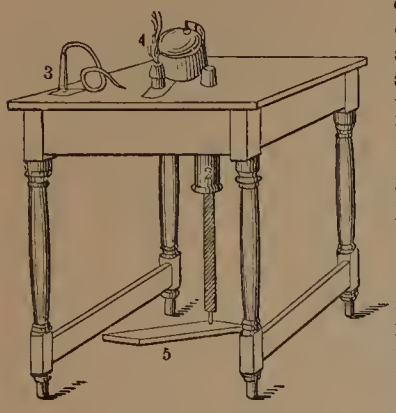


Table Blow-Pipe.

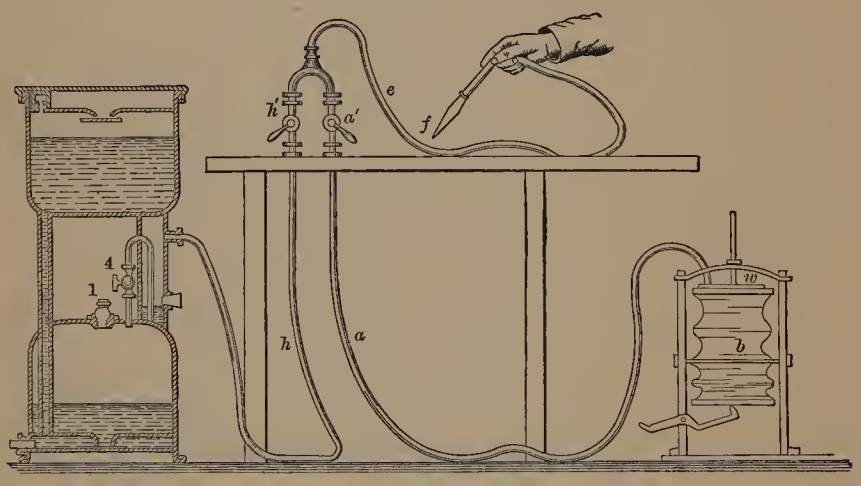
ing the two gases, oxygen and hydrogen, from separate reservoirs in a single jet, in the proportion to form water, — namely, 2 volumes of hydrogen, 1 of oxygen, — the compound being ignited just beyond their point of mixture. No substances are found capable of resisting the high temperature obtained by this blow-pipe. Carbonate of magnesia is very difficult to melt, but even this is reduced into grains of enamel of sufficient hardness to scratch glass. Platinum melts instantly, and gold in contact with borax is entirely volatilized. Pure lime and its compounds emit a flame of amethystine tinge as they melt. Quartz crystal melts with a beautiful light; pieces of china-ware are fused into crystals, and flints produce transparent glass. The intensity of the light emitted in fusing pure lime caused this invention to be recommended by Lieutenant Drummond, of the British Engineers, as an illumination for lighthouses, and it is now known as the Drummond light. Dr. Hare used an instrument terminating in fifteen jet pipes of platinum. These were adjusted so as to pass through a vessel filled with ice or snow, to prevent the gases becoming heated, and obviate the danger of an explosion by a retrocession of the flame into a single pipe. Dr. Clarke, of Cambridge, England, inclosed in the pipe containing the two gases a great number of layers of fine wire gauze, to prevent explosion; though his experiments were successful in a scientific view, the apparatus proved too dangerous for common use. M. Goldsworthy Gurney contrived an instrument in which the gases were forced from their reservoirs through a tube to the bottom of a chamber containing water, the gas rising through the water and passing immediately to the burner; a stiff pasteboard cap closely covered the reservoir, sufficiently strong to retain the gas, which, in case of an explosion, would be easily thrown off, and retrocession of the flame into the gas-chamber prevented by the volume of water. A bottle or flask half filled with mercury or oil of turpentine, connecting by leaden tubes between the reservoir and jet, like the arrangement of a Woulf's bottle, has also been used to prevent explosion. The gas rises in bubbles through the contents of the bottle or flask, and in case of an explosion retrocession of flame is prevented, either by the mercury being driven into the pipe, forming a mechanical obstruction, or in case of an explosion on the surface of the turpentine, a non-explosive compound is formed by the excess of carbonaceous matter, rendering it impossible for the flame to reach the reservoir.

The *airo-hydrogen* blow-pipe is a modification of the oxyhydrogen blow-pipe invented by Dr. Hare, of Philadelphia; the modification being the invention of Count de Richmont, of France.

The elastic tube *h* supplies hydrogen from the generator, and the pipe *a* supplies atmospheric air from the small pair of double bellows *b*, worked by the foot of the operator and compressed by a constant weight *w*. The two pipes meet at the arch and proceed by a third pipe *e* to the small jet *f*, from whence proceeds the flame. All the connections are by elastic tubes. In using the machine, the hydrogen is ignited and the size of the flame regulated by the stop-cock *h'*; the air is then admitted through *a'* until the flame assumes a fine pointed character, with which the work is united after the general manner of blow-pipe soldering, except that a strip of lead is used instead of solder, and generally without any flux. See BURNING.

The gas-generator is charged through the stopper-hole 1 with curly shreds of sheet zinc, and the stopper replaced. The pipe of communication between

Fig. 738.



Airo-Hydrogen Blow-Pipe.

the upper and lower chambers being plugged or closed by a leaden stop-cock, the upper chamber is charged with dilute sulphuric acid (1 acid, 6 water). As the acidulated water reaches the zinc, hydrogen gas is evolved by the decomposition of the water, and passes off by cocks 4 and *h'*. When the outflow ceases by the closure of cocks 4 and *h'*, gas generated fills the chamber, and, pressing on the surface of the liquid in chamber 1, drives it into the upper chamber, so that the evolution of gas is stopped. When gas is withdrawn, the liquid returns and the production of gas is resumed. The generator chambers are of lead, to preserve them from the action of the acid.

In the oxyhydrogen blow-pipe, oxygen 1 volume and hydrogen 2 volumes are united in proportions to constitute water. In the airo-hydrogen blow-pipe the same gases are in the same proportions, but the oxygen is, so to speak, diluted by four times its bulk of nitrogen.

Blow-through Valve. (*Steam-Engine.*) A valve commanding the opening through which boiler-steam is admitted to a condensing steam-engine to *blow through* and expel air and condensed water, which depart through the way of the *snifting-valve.*

This is the first operation in starting an engine of this character, the condenser being then brought into operation to condense the vaporous contents of the cylinder and make the first stroke.

Blow-tube. 1. The hollow iron rod used by glass-makers to gather *metal* (melted glass) from the pots, to blow and form it into the desired shape. A *ponty*. (Fr. *pontil*.)

2. A tube through which arrows are driven by the breath. See BLOW-GUN; AIR-GUN.

Blow-up Pan. (*Sugar-Machinery*.) A pan used in dissolving raw sugar preparatory to the process of refining. Steam is introduced by means of pipes coiled round within the vessels to dissolve the sugar, which thence becomes a dark, thick, viscous liquid; a small portion of lime-water is admitted to the sugar, and constant stirring with long slender rods assists the process of liquefaction. The blow-up pans are generally rectangular, 6 or 7 feet long, 3 or 4 feet wide, and 3 feet deep, with perforated copper pipes near the bottom, though the holes of which steam is blown into the sugar.

Blow-valve. (*Steam-Engine*.) The valve by which the air expelled from the cylinder escapes from the condenser on the downward stroke of the piston when a steam-engine is first set in motion. The *snifting-valve*.

Blub'ber-guy. (*Nautical*.) A rope stretched between the mainmast and foremast heads, and serving for the suspension of the *speck-purchase* used in *flensing* whales under the orders of the *specktioneer*.

Blub'ber-spade. (*Nautical*.) A keen-edged, spade-like knife, attached to a pole, used by whalemen in removing the layer of fat or blubber which encases the body of a whale.

The carcass, stripped of the blubber, is called *krang*.

Blue-light. A signal light burning with a steady blue color.

Blue-lights are made of a composition of 9 lbs. 10 oz. saltpeter, 2 lbs. 6½ oz. sulphur, 11 oz. red orpiment. The materials are well pulverized and thoroughly incorporated, and a sufficient quantity for a charge is pressed into a hemispherical cup of seasoned wood, having a handle about ten inches long. These cups are covered with cartridge-paper pasted over the mouth, and are primed with quick-match. When lighted, they are held by the handle until the composition burns out.

Blue-met'al. (*Metallurgy*.) One condition of copper in course of refining. The names *coarse-metal*, *fine* or *blue metal*, *coarse copper*, and *rose-copper* occur in that order. See COPPER.

Blu'ing. 1. (*Metal-working*.) The process of heating steel until it assumes a blue color. See TEMPERING.

2. (*Dyeing*.) Coloring goods by a solution of indigo.

Blun'der-bus. A short gun with a large bore, for carrying a large charge of balls and slugs, to be used at close quarters. In former times, the same body of troops seem to have been armed part with carbines and part with blunderbusses (Dutch, *donderbus*, thunder-gun). It is now disused, and we seldom hear of it except in accounts of old houses and mansions where it is provided against burglars. This is a mere reminiscence, and has no practical bearing upon the modern armorer's art.

Blung'ing. (*Pottery*.) The process of mixing clays for the manufacture of porcelain. The proper proportions of the clays and the needful quantity of water are placed over night in a trough about 2½ feet deep. The ingredients are intimately mixed by the *blunger* (corrupted from *plunger*), which is a long blade shaped like a spatula, but larger than a shovel, and having a cross-handle by which it is wielded. The material is mixed till it becomes a smooth and plastic mass, a pint of which weighs from 24 to 26 ounces, according to the ingredients.

The work is sometimes done in a pug-mill, which saves very hard manual labor.

Blunk. (*Fabric*.) A heavy cotton Scotch cloth.

Blunt-file. A file which has but slight taper. It is a grade between the regular *taper* and the *dead-parallel* files.

Blunt-hook. (*Surgery*.) An obstetric hook for withdrawing the fœtus without piercing or tearing.

Blunts. A grade of sewing-needles whose pointed ends are less finely attenuated than the *sharps*. *Betweens* are a middle grade in this respect.

Board. 1. (*Wood-working*.) *a*. A sawed piece of wood, relatively broad, long, and thin, exceeding 4½ inches in width and less than 2½ inches in thickness. The term *plank* is properly applied to a grade thicker than *boards*, though the two terms are often used indiscriminately. What in shipwrighting, etc., are called plank, would in house-carpentry usually come under the denomination of *scantling*.

According to the British system, fir-boards under nine inches in breadth are called *deals*, and boards of greater width *planks*.

b. A rived slab of wood; as, a *clapboard*.

The following terms obtain: —

Feather-edged; one edge thinner than the other.

Listed; the sap-wood removed.

Edge-shot; the edge planed.

Wrought; planed on the side.

Matched; tongued and grooved.

Jointed; lined and edge-planed so as to come together correctly.

2. A flat piece of plank or a surface composed of several pieces, used in many trades; as, —

Modeling-board; a templet having the profile of the gun or cylinder formed by the loam-molding process.

Follow-board; a supporting-board on which a pattern lies in molding.

Molding-board; flask-board on which the box is placed in sand-molding.

Dead-head board, cascabel-board, back-board, molding-out board, are also used in loam-molding operations.

3. (*Paper*.) A thick paper, composed of several layers pasted together; *pasteboard*. There are various terms employed to express different varieties.

a. *Cardboard* is made of thicknesses of more common paper pasted together, and having a fine quality for surfaces.

b. *Bristol-board* has fine paper throughout its substance.

c. *Mill-board* is made of coarse material, with a glossy surface produced by heavy rolling.

d. *Enameled-board* has a coating of white lead or other pigment.

e. *Glazed board* has a smooth glazed surface.

f. *Tar-board* is made of junk and rope.

g. *Straw-board* is a yet poorer quality, made of straw-paper.

h. *Pressing-boards;* very hard and smooth calendered boards, between which printed sheets are pressed.

4. (*Bookbinding*.) *a*. A flat slab of wood used by bookbinders. They are known by names indicating their purpose; as, backing, burnishing, cutting, gilding boards, etc.

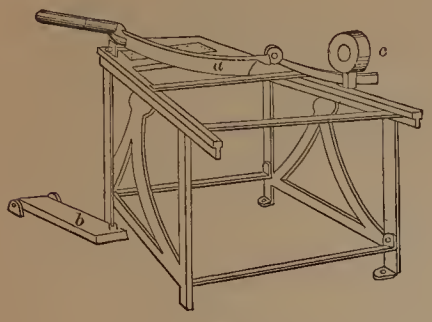
b. Pasteboard sides for books.

5. A level table or platform on which a game is

played ; as, chess, checker, backgammon, cribbage boards.

Board-cut'ting Knife. (*Bookbinding.*) A hinged knife *a* with a counter-weight *c*, and a treadle *b* to assist in making the cut. The board or pile of

Fig. 739.



Board-Cutting Knife.

boards is laid upon the table and pushed up against the gage, which is set for the width of the pieces to be cut.

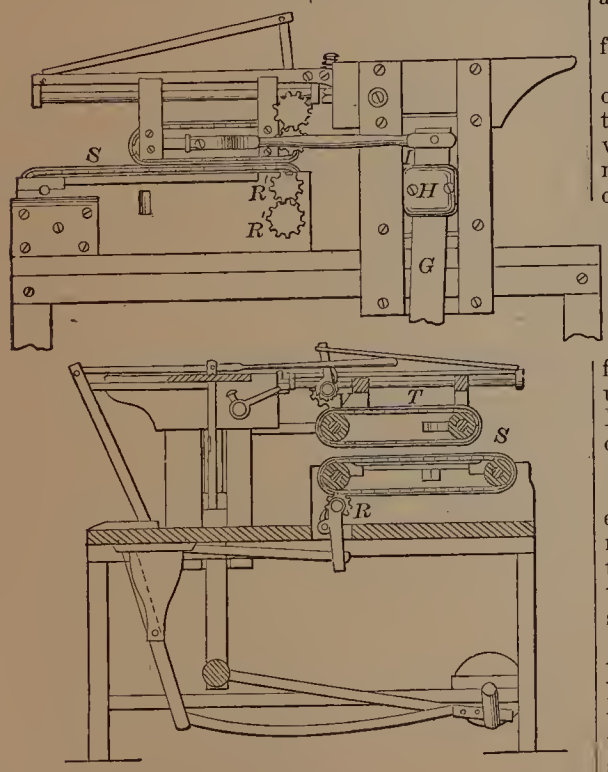
Board'ing. (*Leather.*) The process of rubbing leather with a board to *raise* the *grain* after it has been shaved, daubed, and dried.

Board'ing-gage. (*Carpentry.*) A graduated scribing-tool used as a measurer of width and distance in weather-boarding sides of houses.

Board'ing-joists. (*Carpentry.*) Joists in naked flooring to which the boards are fixed.

Board'ing-ma-chine'. In Fig. 740 is shown a machine in which the leather is carried between

Fig. 740.

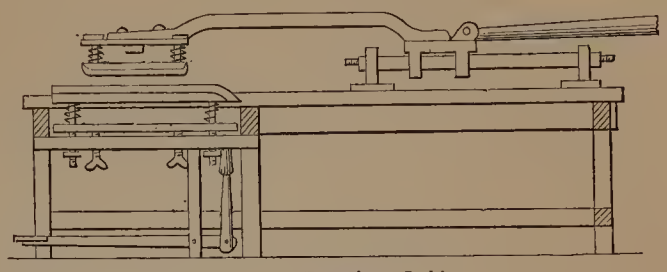


Boarding-Machine.

two endless aprons *T S*, which revolve intermittingly so as to feed in the leather occasionally, while at the same time the upper apron *T* has a reciprocating motion, adjustable in extent, upon the lower roll *S*. The upper and lower roll respectively are moved a certain distance at each rotation of the drive-wheel by the ratchets *V* and *R* respectively. The reciprocation of the upper roll is by means of the lever *G*, adjustable pivot-box *H*, and pitman *I*.

In Fig. 741 is a simpler form of boarding and

Fig. 741.



Boarding-Machine.

graining machine, in which a spring-pad is reciprocated over a spring-bed.

Board'ing-net'ting. (*Nautical.*) Strong nettings of cords, to prevent boarding of a ship in battle.

Board'ing-pike. (*Nautical.*) A pike used on shipboard to repel boarders.

Ship-spears or boarding-pikes are represented in the sea-fight at Medinet Aboo, in Egypt.

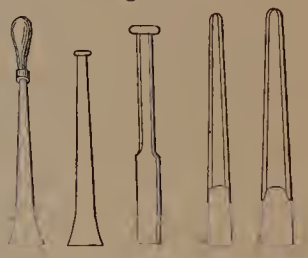
Board-rack. (*Printing.*) Side boards with cleats to hold shelves for standing matter.

Boast'er. (*Masonry.*) A stone-mason's chisel, having an edge two inches wide, used in dressing down the surface of stone. It is intermediate in width between the *inch-tool* and the *broad tool*, which are respectively 1 inch and 3½ inches wide.

Boast'ing. 1. (*Masonry.*) Dressing off the surface of stone with a broad chisel and mallet.

2. (*Sculpture and Carving.*) The roughing out of an ornament, giving the general contour previous to the commencement of the raffles and other details.

Fig. 742.



Boasting-Chisels.

Boast'ing-chis'el. A steel chisel with fine broad edge, used by marble-workers for dressing stone to a nearly smooth surface preliminary to the use of the *broad-tool*. Forms adapted to various kinds of work are shown in Fig. 742.

Boat. A small water-craft.

Boats were one of the earliest devices of nature to enable some of the denizens of the ancient deep to maintain themselves with ease upon the surface of the waters, which their physical structure rendered them ill qualified to do without an extraneous support.

Such were the numerous cephalopod mollusks, as the ammonites, the orthoceratites, and other varieties having chambered shells, which flourished in the waters of the ancient world, and at a later epoch the nautili, species of which still inhabit our warmer seas. Nor are contrivances of this kind confined alone to existences designed to permanently inhabit the waters ; a similar provision is made for the temporary support of some insects whose larvæ attain their development in water, as the gnat tribe, including that peculiarly social and familiar insect, the

mosquito, whose tender regard for the human race is so touchingly manifested and loudly proclaimed. "A beast familiar to man and signifying—love."

The boat formed by the female gnat consists of from 250 to 350 eggs, and though each is heavy enough of itself to sink in water, the whole structure is perfectly buoyant. Though hollow, it never fills with water, as the surface has a certain repellent action. This little craft has been likened to a river wherry, being sharp, high fore and aft, convex below, concave above, and always floating keel down.

The canoe was probably the first form of boat which succeeded the simple raft, which had supplanted the humble log upon which man first entrusted himself upon the waters. It was much easier to partially burn out a large log, and then finish the work with a pointed stone, than to construct in any other way, with similar tools, a vessel combining equal convenience and speed, and accordingly we find the canoe thus constructed among most primitive nations.

The canoe was the ordinary form of boat in the New World when discovered by Columbus. During his fourth voyage he landed on one of the Guanaja Islands, and was visited by a large trading-canoe remarkable for its size and freight. It was eight feet wide, but formed of a single tree. An awning inclosed a cabin occupied by the wives and children of the cacique, and it was propelled by twenty-five rowers. It was supposed to have come from Yucatan, forty miles distant. The voyagers were clothed with cotton mantles; their bread was made of Indian corn, and they had a beer on board made of the same grain. They had also copper bells, plates, and hatchets as freight.

The endurance and sea-going qualities of some boats of this description are almost incredible; those of the South Sea Islanders and of the inhabitants of the northwest coast of America often make voyages of hundreds of miles, the latter in an inclement and tempestuous ocean; instances are known of the South Sea Island canoes, accidentally blown off from their own island, keeping afloat for months and drifting hundreds of leagues.

A farther advance consisted in the employment of some pliable substance, as hides or birch-bark, sewn together, where the proper materials could be procured.

Ulysses, the hero, made his own boat.

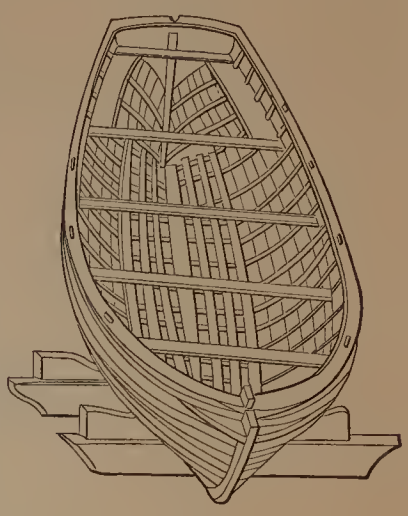
"The boats which come down the river [Euphrates] to Babylon are circular, and made of skins. The frames, which are of willow, are cut in the country of the Armenians, above Assyria, and on these, which serve for hulls, a covering of skins is stretched outside, and thus the boats are made without either stem or stern, quite round like a shield." — HERODOTUS, I. 193.

The modern boats of the Euphrates are of closely woven willow payed with bitumen.

For capability of living in a heavy sea or landing in a heavy surf, no boat constructed can compare with the catamaran (which see), a simple raft formed of three or more logs of light wood, connected together by wooden cross-ties, and having a slightly elevated platform for its occupants to sit on; these are in common use on the coasts of Hindostan and South America, especially for landing goods and passengers through a heavy surf, which they do in safety, when a common ship's boat would be almost instantly dashed to pieces.

Boats built of boards or planks being, in civilized countries, of easier and cheaper construction than any others, and combining great strength with lightness and facility of repair, are generally employed for most purposes, though of late years boats made of corrugated sheet-metal have come into use to a considerable extent. These combine durability, safety, strength, and lightness in the highest possible degree, and for life-boats or for use in harbors, where establishments at which they can be repaired are easily accessible, they seem to unite every desirable requisite; but the impossibility of their repair by an ordinary carpenter, or with the means usually at hand on board ship or in most foreign ports, renders them objectionable in that respect, though when properly made they are little liable to accident. See LIFE-BOAT.

Fig. 743.



Boat.

Paper boats are made by fitting sheets the length of the boat over a model of the exact form; successive sheets, breaking joint, are laid on with a coat of varnish between each. Model and paper envelope are removed to a drying-room, and then payed with boiled oil and turpentine, and then with shellac varnish. The shell is then fitted with an inner frame, thwarts, and the usual appendages.

Ship's boats are named according to their sizes or the nature of their duty. They are known as —

Launch,	Carvel-built.
Long-boat,	
Barge,	
Pinnace,	
Yawl,	
Galley,	Clinker-built.
Gig,	
Cutter,	
Jolly-boat,	
Dingy,	

Boats are also known by their purpose or duty; as, —

Advice-boat,	Snag-boat,
Canal-boat,	Stone-boat,
Dispatch-boat,	Submarine-boat,
Ferry-boat,	Surf-boat,
Ice-boat,	Tender-boat,
Life-boat,	Torpedo-boat,
Packet-boat,	Tug-boat,
Passage-boat,	Whale-boat, etc.
Pilot-boat,	

Also by specific names of various imports; as, —

Bateau,	Keel,
Coracle,	Metallic-boat,
Buggy-boat,	Punt,
Bunder-boat,	Scow,
Caique,	Sectional-boat,
Dory,	Skiff,
Flat-boat,	Steam-boat,
Folding-boat,	Wherry, etc.,
Gondola,	

most of which are described under their respective heads.

Boat-bridge. A boat-bridge consists of a track laid on a number of boats anchored parallel in the stream, or moored to ropes or chains which pass from bank to bank.

The bridge thrown across the Hellespont by Xerxes when he invaded Greece, 480 B. C., had a length of 500 paces, and was supported on ships used as *pontons*. Suspension cables of flax and biblos united the ships, transverse beams were laid on the cables; the beams supported plank and earth, and the army marched across, bag and baggage.

Many years after, there appears to have been a more permanent construction of this nature in the same vicinity.

"At Abydos is the Zeugma [or Junction], a bridge of boats which could be unfixed at pleasure for the passage of vessels." — STRABO.

Cyrus, according to Xenophon, crossed the Meander on a bridge supported by seven boats.

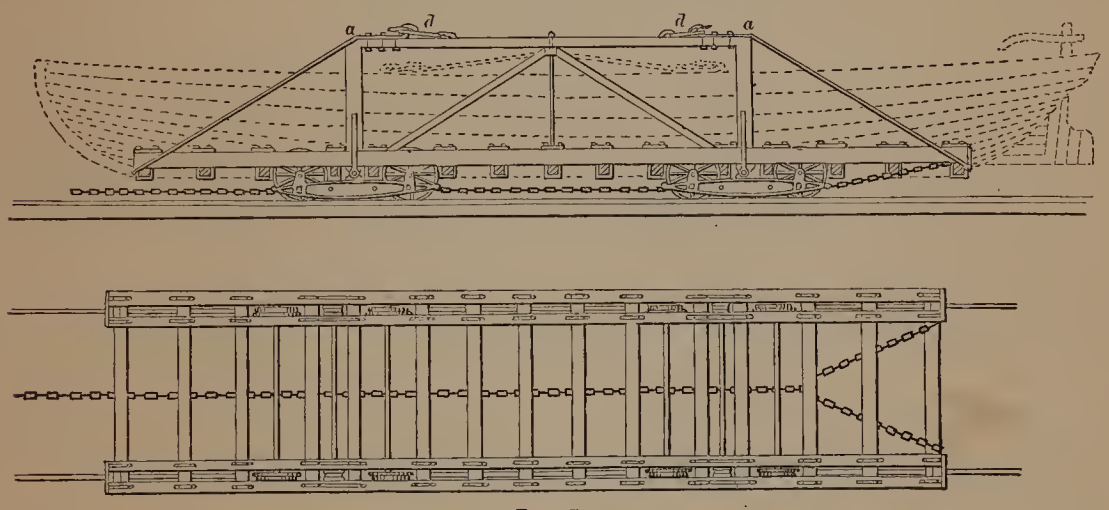
Bridges of boats were in general use in the Middle Ages, and are still used on the Continent of Europe. One at Strasbourg is 1,300 feet long, and there is another at Cologne. One across the Seine at Rouen was constructed by Nicolas in 1700.

Boat-bridges, in a military point of view, are classed as ponton-bridges, the pontons or bateaux and the road-bed being transported on wagons with the army, and thrown across streams as necessity may occur. The bateaux are moored to ropes secured to trees or other safe objects on the respective sides of the river. See PONTON-BRIDGE.

Boat-car. A car adapted for transporting boats up and down inclined planes.

The Morris and Essex Canal in the State of New Jersey leads from Jersey City, on the Hudson, to Easton, on the Delaware, and connects these two rivers. The breadth at the water-line is 32, and at the bottom 16 feet, and the depth is 4 feet. It is 101 miles in length, and is said to have cost $3,000,000. It is peculiar as being the only canal in America in which the boats are moved from different levels by means of inclined planes instead of locks. The whole rise and fall on the Morris Canal is 1,557 feet, of which 223 feet are overcome by locks, and the remaining 1,334 feet by means of 23 inclined planes, having an average lift of 58 feet each. The boats which navigate this canal are 8½ feet in breadth of beam, from 60 to 80 feet in length, and from 25 to 30 tons burden. The greatest weight ever drawn up the planes is about 50 tons. The boat-car used on this canal is shown in elevation and plan, the boat being shown in dotted lines. It consists of a strongly made wooden crib or cradle *a*, on which the boat rests, supported on two iron wagons running on four wheels, upon plate-rails laid on the

Fig 744

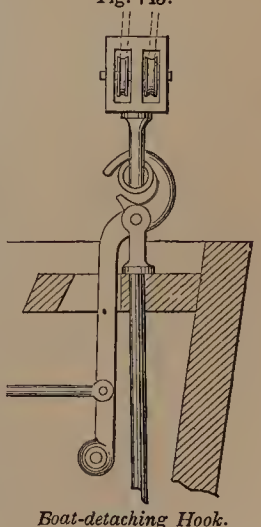


Boat-Car.

inclined planes, and raised and lowered by means of machinery driven by water-wheels. The railway on which the car runs extends along the bottom of the canal for a short distance from the lower extremity of the plane; when a boat is to be raised, the car is lowered into the water, and the boat, being floated over it, is made fast to the part of the framework which projects above the gunwale, as shown in the drawing at *d*. The machinery is then put in motion, and the car, bearing the boat, is drawn by a chain to the top of the inclined plane, at which there is a lock for its reception. The lock is furnished with gates at both extremities; after the car has entered it, the gates next the top of the inclined plane are closed, and, those next the canal being opened, the water flows in and floats the boat off the car, when she proceeds on her way. Her place is supplied by a boat traveling in the opposite direction, which enters the lock, and, the gates next the canal being closed and the water run off, she grounds on the car. The gates next the plane are then opened, the car is gently lowered to the bottom, when it enters the water, and the boat is again floated.

Boat-de-tach'ing Hook. (*Nautical.*) One adapted to be suddenly cast loose when a boat lowered from the davits touches the water. It is important that the hooks which engage the eye-bolts, stem and stern, should be instantly and simultaneously disengaged when the boat touches water. This is done by upsetting the hooks, the opening of sister-hooks, or the tripping of a trigger.

Fig. 745.

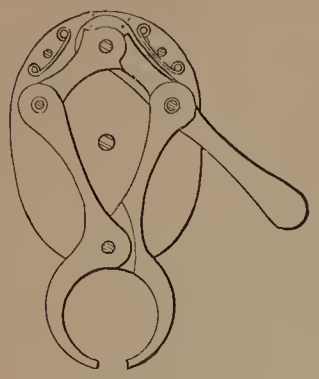


Boat-detaching Hook.

In Fig. 745 the boat is attached to the davit-blocks by the hooks of pivoted levers connected together so as to ensure simultaneous release. The pivot-supports of the hook-levers have projections preventing release before the hooks are turned up.

In Fig. 746 the incurved lower ends of the levers form jaws, which are operated by a toggle at the upper ends of the levers. Each half of the hook forms a mousing for the other.

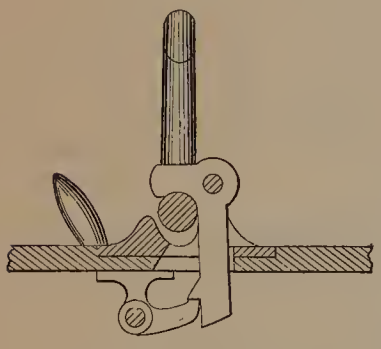
Fig. 746.



Davit-Block Hook.

In Fig. 747 the hook or link at the end of each davit-fall passes under one branch of a pivoted arm, the other branch of which has a projection held by a pivoted catch, turning on a shaft running lengthwise of the boat. By turning a handle attached to this shaft, the two catches retaining the arms simultaneously release them, allowing them to slip off the hooks or links of the davit-falls.

Fig. 747.



Boat-Detaching Hook.

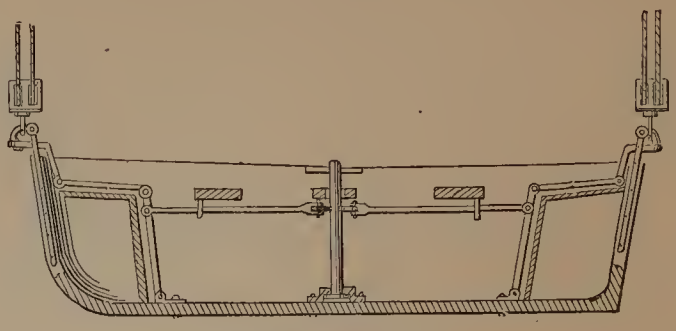
Boat-hook. A pole whose end is furnished with an iron having a point and a hook. It is used for holding on to a boat or other object, and is a part of the boat's appurtenances.

Also known as a *gaff; setter; setting-pole; pole-hook; hitcher.*

The *contus nautarium* of the ancients.

Boat Low'er-ing and De-tach'ing Ap-pa-ra'tus. The ordinary boat lowering and hoisting apparatus consists merely of two falls passing through double blocks and suspended from the davits. The lower blocks hook into rings at each end of the boat, and are unhooked by hand after the boat is lowered. In lowering a boat in a heavy sea, this arrangement is troublesome and inconvenient, as a failure to detach both hooks simultaneously may lead to the swamping of the boat. To remedy this, and to enable both ends of the boat to be cast off at one operation, a number of contrivances have been devised. These devices generally take the form of means for casting loose the hooks fore and aft with absolute certainty and simultaneously. Sometimes it is a rod which is withdrawn so as to let the hooks fly loose. Of this character is the device shown in Fig. 748, in which the eyes of the davit-fall blocks are engaged by pivoted hooks at the stem and stern respectively of the boat. The hooks are detained by links, which are simultaneously withdrawn by lever connection with a rotating shaft amidships.

Fig. 748.

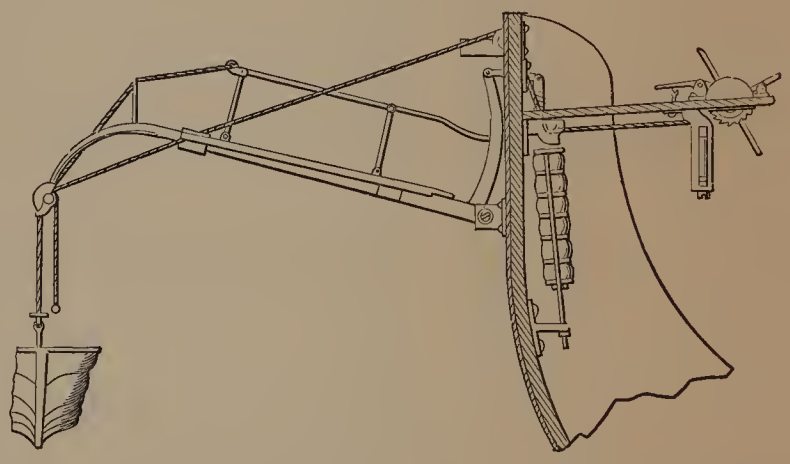


Boat-Detaching Tackle.

There are various modifications of this form of the device.

In Fig. 749 the davits are hinged in such manner as to swing freely in vertical planes toward and from the water, and to vibrate above and below a horizontal plane intersecting their axis of motion.

Fig. 749.



Boat-Lowering Davits.

Curved sections are applied to the upper ends of the davits, which are hinged at their lower ends, so that said sections can be turned around independently of the standards to which they are attached.

The davits are counterpoised by a force sufficient to raise them without the boat, but easily overcome by the weight of the boat.

Bob. 1. (*Metal-working.*) A small buff-wheel used in polishing the insides of spoons. It is a disk of leather nearly an inch thick, known as *sea-cow* or *bull-neck.* It is perforated, mounted on a spindle, and turned into a nearly spherical form.

2. (*Horology.*) The weight of a pendulum.

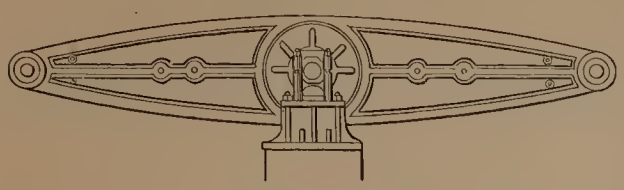
3. The suspended ball of a *plumb-line.*

4. The shifting weight on the graduated arm of a *steelyard.*

5. (*Mining.*) A rocking-post framed into a pivoted bar and driven by the crank of the water-wheel or engine-shaft. To one end of the beam is suspended the pump-rod, and the other is counterweighted to balance the said rod.

6. (*Steam-Engine.*) A working-beam.

Fig. 750.



Engine-Bob.

Bob'bin. (*Sewing-Machine.*) A small spool adapted to receive thread and to be applied within a shuttle.

(*Spinning.*) A spool with a head at one or both ends to hold yarn. It has one head when it serves as a cop in spinning, as a thread-holder in shuttles of looms, and as cop in warping-machines. In spinning or warping it is slipped on a spindle and revolves therewith, being held thereon by a spring or by the tightness of its fit.

It has two heads when used as a spool for sewing-thread, as a bobbin for sewing-machine shuttles, and sometimes as a warp-holder in looms where each warp is independent.

The Wheeler and Wilson sewing-machine has a circular bobbin of lenticular shape, which holds the lower thread, and is dropped through the loop of the upper thread, distended for that purpose by the rotating hook.

Braiding-machine bobbins have two heads, the upper one notched as a ratchet, to receive the stopping-arm attached to the let-off mechanism. GREENHALGH'S Patent, April 13, 1869. The bobbin rotates freely on its shaft; its thread passes through an eye in a standard and one in a tension-weight sliding thereon. The stopping-arm is attached to a sleeve on the standard, and is supported in the ratchet-openings of the bobbin-head until the tension-weight is raised by the thread to trip it and release the bobbin, which then rotates freely and pays off the thread until the slack allows the tension-weight to fall and release the stopping-arm, which again engages with the head of the bobbin.

Bobbins are variously constructed, and of divers materials.

Materials, — clay, wood, ivory, hard rubber, porcelain, glass, papier-maché, corrugated metal, malleable cast-iron.

Having metallic barrels and disks of the same for heads; of wood turned; of cylinders with one head each, and slipping one into the other telescopically; with paper bodies; polygonal prisms with buttons on the ends; having a number of different-sized circumferential grooves.

Bob'bin and Fly Frame. The ordinary *roving-machine* of the cotton manufacture. Its duty is to draw and twist the *sliver*, and wind the roving on a bobbin.

The *bobbins* containing the *slivers* are mounted in several rows on a *creel* which has *skewers* for their reception. Each sliver passes between a pair of guides, which give it a horizontal traversing motion, so that it shall not bear upon a constant part of the surfaces of the drawing-rollers between which it next passes. These drawing-rollers are arranged in pairs (see DRAWING-FRAME), and have a relatively increasing rate of speed, the second revolving faster than the first and the third faster than the second. This proportion may be, say, first rollers 1 inch in diameter and 60 turns per minute; delivering rollers, 1¼ inches in diameter and 180 turns per minute. By this proportion the first roller would deliver 188.4 inches per minute, while the *front* or delivery pair passes 705.5 inches per minute, the roving becoming elongated 3¾ turns by the operation.

After leaving the rollers the sliver is received by the spindles, which are arranged in two rows for economy of room. The vertical spindles are driven by bevel-wheels from bevel-pinions, or horizontal shafts extending the whole length of the machine. Supported upon each spindle is a *flyer*, which has a hollow axis and a hollow arm, through both of which the roving passes in order to reach the bobbin, which is placed upon the spindle, and revolves loosely thereon by its own positive motion, derived from bevel-gearing, shown beneath it in the figure. The lower bevel-gearing is for the rotation of the *spindle* and *flyer*, and gives the twist. The upper bevel-gearing is for the rotation of the *bobbin*, and winds the *roving* thereon. The flyer has one tubular arm to lead the roving, and one solid arm which acts as a counterbalance to the former to prevent agitation during the rotation at high speed, say 1,300 revolutions per minute.

The bobbin has two motions, — one around the spindle on which it is sleeved, and one up and down on the spindle. The former is for the winding on of the roving, and the latter to distribute the roving in coils alongside each other along the length of the bobbin.

There are three inequalities to the motion of the bobbin, — one in the rate of its revolution, another in the length of its vertical traverse, and a third in the rate of its traverse. The inequality of rotation is for the purpose of winding equal roving in equal time, notwithstanding the increasing diameter of the *cop*. The rate of winding on is of necessity equal to the rate of delivery from the *front* pair of drawing-rollers, and it follows that the rate of winding must be uniform. As layer after layer of coils accumulates upon the bobbin, the latter receives a decrease of speed exactly equivalent to its increase of diameter. This is accomplished by *cone*-pulleys by which the driving-band is shifted to a part of the *driven*-pulley having a larger diameter, the band having a constant rate. See CONE-PULLEYS.

The vertical motion of the bobbins is by means of raising and lowering the *copping-rail* on which the whole row or the two rows of bobbins rest, sliding the bobbins up and down on the spindles. The inequality of *length* of vertical motion is for the purpose of giving a gradually decreasing length to each successive layer of coils, giving a conical end to the completed cop, so that each layer contains an equal length of roving, its diminution in length counterbalancing its increase in diameter. The inequality of *rate* of vertical motion is to enable the yarns to lie compactly side by side in the coils, notwithstanding the changes in the rate of revolution due to changes in the diameter of the *cop*.

While the *twist* depends upon the rotation of the *spindle* and *flyer*, the degree of twist depends upon the ratio between the delivery at the front pair of *drawing-rollers* and the revolutions of the spindle. "The winding on of the twisted roving upon the bobbin is effected by giving to the bobbin such a velocity that the difference between the motion of the surface of the bobbin and the motion of the delivering end at the arm of the flyer shall equal the surface-motion of the roller or the supply of the sliver. The spindle and bobbin being driven by different movements and at different rates, the winding is effected either by making the bobbin revolve a little faster than the spindle, or the spindle faster than the bobbin. If, for example, the bobbin revolves 50 times while the spindle only revolves 40, 40 turns of

the bobbin will have nothing to do with the winding; but there are 10 turns of the bobbin above those of the flyer, which will perform the winding. Hence the 40 turns of the spindle produce twist, while the 50 turns of the bobbin produce 10 coils of the roving upon its barrel."—TOMLINSON.

Bobbin and fly frames are of two kinds, *coarse* and *fine*, or *first* and *second*.

The *coarse*, or *first*, *bobbin and fly frame* acts upon *slivers* from cans filled at the *drawing-frame* and placed at the back of the machine.

The *fine*, or *second*, *bobbin and fly frame* acts upon *rovings*, or *slubbings* as they are often called, from *bobbins* filled at the first frame and placed on the *skewers* of the *creel* placed behind the *roller-beam*.

The object of the repetition is to obtain a greater degree of *drawing* and *twist* than could be safely imparted at the first operation, when the *sliver* or *card end* had but little coherence.

In the coarse bobbin and fly frame it is usual to make the spindle revolve quicker than the bobbin, and in the fine frame to make it go slower. The relation of the speed and proportions are well explained by Dr. Ure with an elaborateness impossible within our limits.

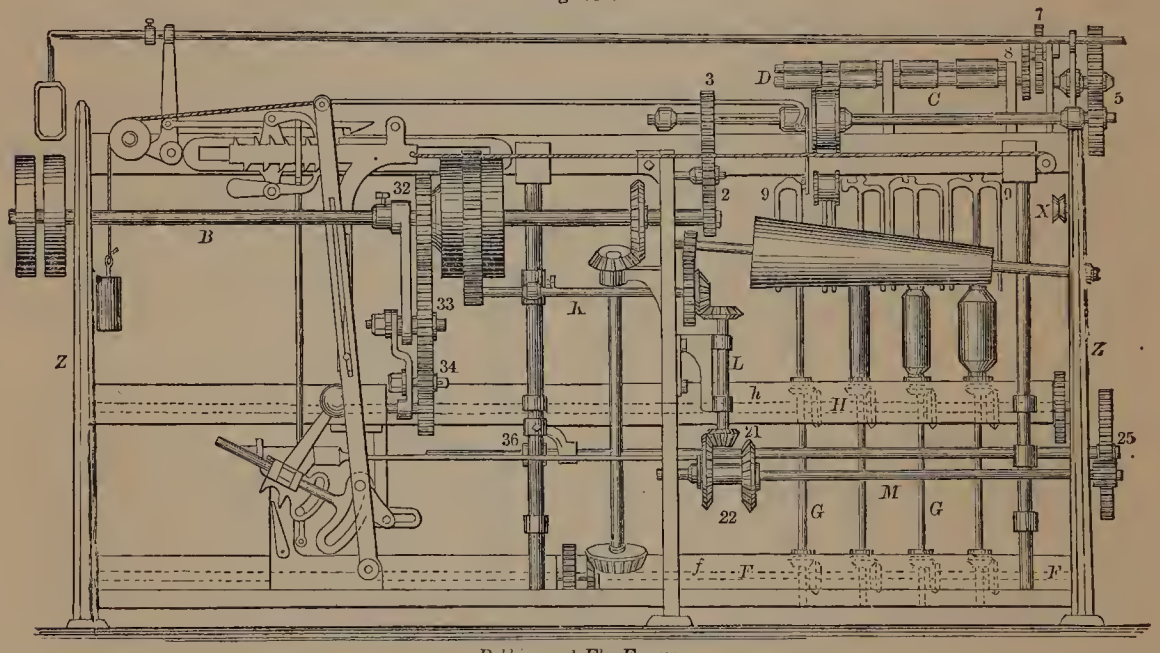
In the coarse roving-frames the spindles make on an average 750 revolutions per minute, turning off for each spindle 400 inches per minute or 666⅔ yards per hour. In the fine frame there is more twisting power, and this produces about 533 yards per hour. In the coarse frame the *sliver* is elongated from four to six times, one quarter of the draft being between the first and second pairs of rollers, and the remaining three quarters between the second and the delivery pairs of rollers.

As the drawing-rollers and the spindles are driven by positive though determinate motions from the same shaft, the number of twists to an inch of the sliver delivered from the front pair of drawing-rollers is uniform after the work is started, irrespective of the rate of winding on the bobbin or the actual speed of the machine. The relation is adjustable before starting by changeable gearing intervening between the main shaft and the spur-wheels of the drawing-rollers. If the drawing-rollers pay out 706 inches of sliver and the flyers make 1,300 revolutions, the amount of twist will be nearly 1¾ to an inch. This is but slight, but is usual in the *first roving-machine*, a draw and twist being afterwards given in the *second roving-machine;* the processes being repeated either in the *throstle* or the *mule*, in one of which the yarn is finished.

For the adjustment of different degrees of twist in different yarns a differential gearing is used. See EQUATIONAL BOX.

B, main shaft, driven by a band from the engine.

Fig. 751.



Bobbin and Fly Frame.

2, 3, 5, 7, 8, *C*, *D*, train for driving drawing-rollers.

F F, long horizontal shaft below the beam *f*, driven by gearing from the main shaft, and driving the spindles *G*.

h, copping-beam on which the bobbins rest, and which is fitted with slides to the end frames *Z*.

9, flyer pressed on to the top of the spindle.

X, pulley for the chain of the weight which counterbalances the weight of the copping-rail.

H, horizontal shaft carrying the bevel gears by which are rotated the disks in the copping-rail *h*, on which the bobbins are fixed to rotate as they traverse up and down on the spindles *G*.

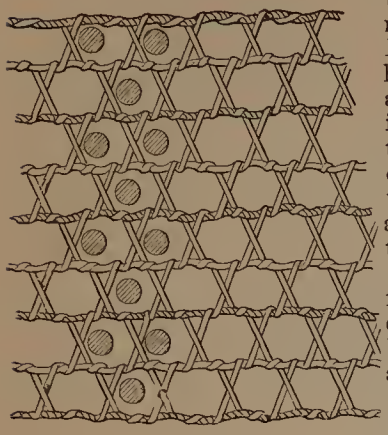
C, *K*, *L*, 21, *M*, 22, 25, shafting and train driving the pinion and rack 36, by which the copping-rail is vertically actuated; right and left bevel-wheels 22 (and another not shown), sliding on shaft *M*, to engage alternately with pinion 21, to give the motions of the copping-rail.

32, 33, 34, train connected with the *cone-pulley* for variable speed, and driving-shaft *H*, which revolves the bobbins by the intervention of bevel-gears. The wheels are connected by elbow-links, so as to mesh, irrespective of the vertical position of the copping-rail *h* and its adjuncts.

Bob-bin-et'. (*Fabric.*) A machine-made cotton net, originally imitated from the lace made by bobbins upon a pillow.

It consists of a series of parallel threads which may be considered as *warp*-threads, and two systems of oblique threads which proceed from the right to

Fig. 752.



Bobbinet.

the left, and from the left to the right respectively. Each weft thread has a single turn around each crossing of a warp, and the contrary strain of the respective weft threads gives a serpentine course to the warps.

The thread that makes the bobbinet is supplied partly from bobbins and partly from a warp. The bobbins are small brass pirns, and swing with a pendulous motion between the warp-threads so as to wrap the weft round the warp.

The bobbinet-machine was originally derived from the stocking-frame, invented by the unfortunate William Lee, M. A., of Cambridge, 1589.

Lee was successively patronized by Elizabeth and by Henry IV. of France. The former liked the stockings well enough, but refused Lee a patent, as the invention was so valuable that it would command the market. The assassination of Henry deprived Lee of a more generous patron, and he fell into poverty, obscurity, and an untimely grave.

Hammond (about 1768) modified a stocking-frame to make a coarse imitation of Brussels ground; this was the *pin*-machine.

In 1784, the *warp-frame* was invented, for making *warp-lace*.

In the next decade, the *bobbin-frame*.

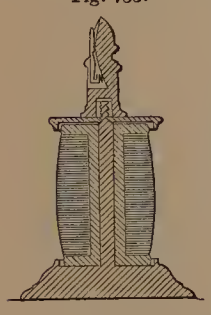
In 1809, Heathcote invented the *bobbinet* machine.

This is a complicated machine, used in but few localities. The parts are very numerous, the motions intricate, and the machine cannot be readily explained within the limits admissible in this work.

Bob'bin-lace. (*Fabric.*) Lace made upon a pillow with bobbins. The pillow is a hard cushion covered with parchment on which the pattern of the meshes is drawn. Pins are inserted into the lines of the pattern and determine the meshes. Thicker thread, called gimp, is interlaced with the meshes, according to the pattern on the parchment. The thread is wound upon bobbins, and is twisted, crossed, and secured by pins. See PILLOW-LACE.

Bob'bin-stand. A frame for holding the bobbins for warps of a loom, threads of a warping-machine, and yarns of a spinning-machine.

Fig. 753.

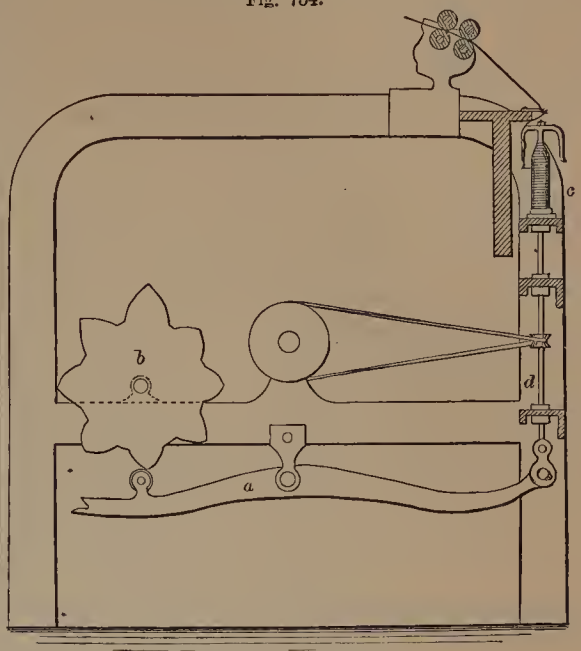


Bobbin-Stand.

The bobbin or reel rotates on a spindle fixed in a base-plate. It is covered with a metallic disk, supported a little above the top of the spool on a shoulder of the spindle, and held down by a screw-nut. An improved form provides flanges or annular lips projecting from the base and cap to inclose the spool-heads, and prevent the twine from catching under the heads. It is surmounted with a twine-cutter.

Bob'bin-wind'er. 1. (*Weaving.*) The thread or yarn is directed to the eye of the guide, which is at the end of a shaft automatically raised and lowered, to lay the thread spirally and conically on the

Fig. 754.

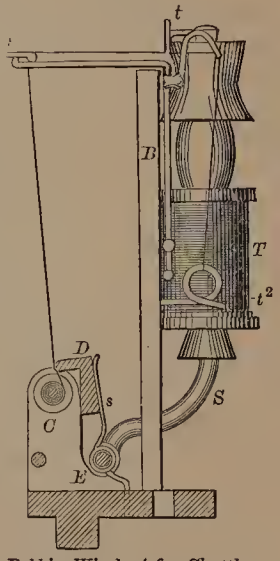


Bobbin-Winder (for Looms).

bobbin by a lever *a* bearing against a cam *b*, so shaped that as the layers of thread are built up, the length of throw increases; the bobbin *c* is supported on a fixed shaft *d* rotated continuously.

2. (*Sewing-Machine.*) A device adapted to receive a shuttle-bobbin and rotate it so that it may be wound with thread. The winders are usually operated by being turned in contact with the driving-wheel, balance-wheel, or band. Some winders are supplied with an automatic thread-distributor, to lay the thread evenly.

Fig. 755.



Bobbin-Winder (for Shuttle-Bobbins of Sewing-Machines).

Winders for the shuttle-bobbins of sewing-machines have arrangements for laying the thread regularly. A traverse guide is automatically reciprocated to lay the thread evenly and compactly, or the bobbin is reciprocated to receive it. When filled, the winding ceases by a stop-motion or through an alarm.

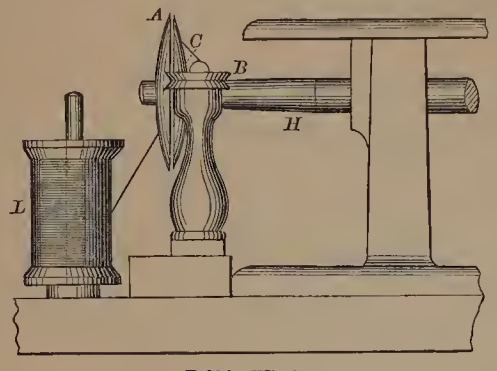
In the illustration, the arbor on which the bobbin is placed is rotated by the temporary contact of a friction-wheel against the fly-wheel of the machine.

The vibrating presser *D* is T-shaped, and is pivoted by its lower end to a horizontal bar *E*, and acted on by a spring *s*. The upper portion or T-head of this presser is somewhat longer than the bobbin *C*, but that portion which impinges against the thread on the bobbin is of such width as to be received between the heads of the bobbin. *S* represents the vertical rod on which the spool *T* is applied. *B* represents a rod which is provided with fixed thread-guides t^1 t^2 and a horizontal vibrating thread-guide *t*.

The winder for lenticular spools of sewing-machines has a spindle on which the bobbin is held while being rotated by the power of the sewing-machine.

The thread from the spool *L*, instead of being held by the fingers as the bobbin revolves, is passed around the tension *B*, and thence to the bobbin *A*. On operating the sewing-machine the thread will be wound up on the bobbin *A*, by the rotation of the

Fig. 756.

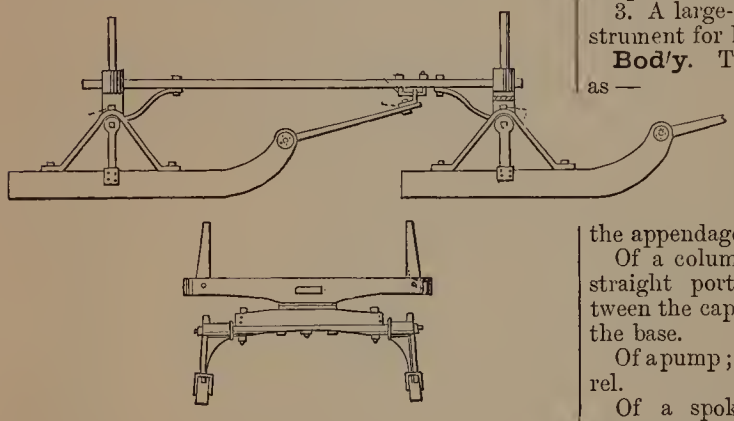


Bobbin-Winder.

shaft *H*, compactly and uniformly by the action of the tension *B*. This will continue until the bobbin *A* is filled, when the thread will override and slip over the edge of the bobbin, down upon the knife *C*, and be instantly cut off.

Bob-sled. A compound sled composed of two

Fig. 757.

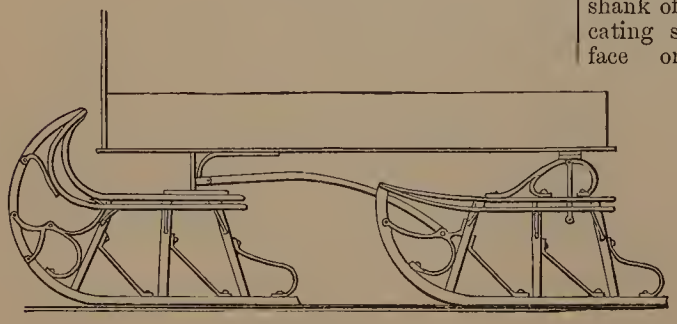


Bob-Sleds.

short sleds, one in front and another behind, connected together longitudinally by a reach.

Bob-sleigh. A sleigh made up of two short (bob) sleighs connected by a reach or coupling. In the illustration, the reach is curved upward to allow the fore bob to pass beneath the reach in turning.

Fig. 758.



Bob-Sleigh.

The body is supported on pendent bars and hanging links.

Bob'stay. (*Nautical.*) One of the chains or ropes which tie the bowsprit end to the stem, to enable it to stand the upward strain of the forestays.

Bob'stay-piece. (*Shipbuilding.*) A piece of timber stepped into the main piece of the head, and to which the bobstay is secured. See STEM.

Bo'cal. (*Glass.*) A glass jar with a short, wide neck.

Boc'a-sine. (*Fabric.*) A kind of calamanco or woolen stuff.

Boc'ca. (*Glass.*) The round hole in a glass-furnace from which the glass is taken out on the end of the pontil.

Boc'ca-rel'la. (*Glass.*) A *small bocca* or mouth of a glass-furnace. A *nose-hole.*

Boc'ci-us-light. A form of gas-burner invented by Boccius, and consisting of two concentric metallic cylinders placed over the flame and within the usual lamp glass, so as to modify the combustion and increase the brilliancy of the light.

Bock'ing. (*Fabric.*) A coarse woolen fabric, originally made at Bocking, England.

Bod'kin. Anciently, a dagger. (Welsh, *bidogyn*, a dagger; diminutive of *bidog*, a sword.)

"Might his quietus make with a bare bodkin."

1. (*Printing.*) A printer's awl, for picking letters out of a column or page in correcting.

2. (*Bookbinding.*) A pointed steel instrument for piercing holes, used by bookbinders and others.

3. A large-eyed and blunt-pointed threading instrument for leading a tape or cord through a hem.

Bod'y. The principal portion of an object; such as —

Body of a carriage or wagon; the part to contain the load.

Of a type; the shank.

Of a boiler, barrel, or bell; the main portion as distinguished from the appendages.

Of a column; the straight portion between the capital and the base.

Of a pump; the barrel.

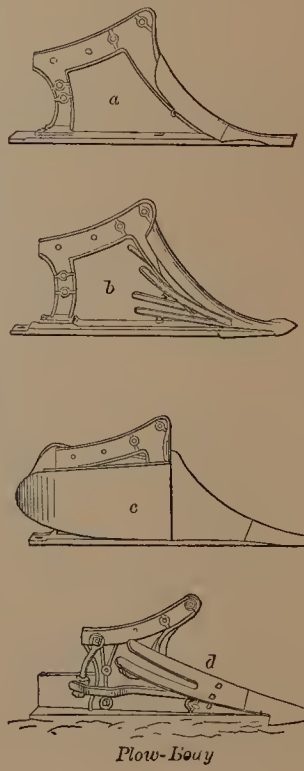
Of a spoke; the part between the hub and felly tenons.

Of a still; the chamber containing the wash; the *cucurbit.*

Of an implement; the part stocked, as of a plow.

1. (*Printing.*) The shank of a type, indicating size, as *agate* face on *nonpareil*

Fig. 759.



Plow-Body

body; larger than the usual body of *agate*, and therefore having the effect of spacing or putting the letters more widely apart.

2. (*Music.*) The upper and resonant portion of an organ-pipe above the *reed* or the *mouth*, by which vibration is imparted to the air.

3. (*Vehicle.*) The bed, box, or receptacle for the load.

4. (*Agricultural Implements.*) The portion of an implement engaged in the active work; as, "various *bodies* of plows may be attached to a plow-stock, according to the work in hand."

a, subsoil body. *c*, ridging body.
b, potato body. *d*, digging body.

Bod'y-hoop. (*Nautical.*) The bands of a built mast.

Bod'y-loop. (*Vehicles.*) An iron bracket or strap by which the body is supported upon the spring bar.

Bod'y of a Place. (*Fortification.*) *a.* The works next to and surrounding a town, in the form of a polygon, regular or irregular. — GRIFFITHS.

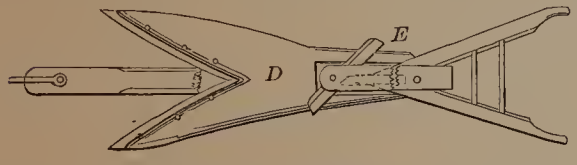
b. The space inclosed within the interior works of a fortification.

Bod'y-plan. (*Shipbuilding.*) An end elevation, showing the *water*-lines, *buttock and bow* lines, *diagonal* lines, etc.

Bod'y-post. (*Shipbuilding.*) The post at the forward end of the opening in the dead-wood in which the screw rotates.

Bog-cut'ting Plow. An implement for cutting and turning up boggy or peaty soil for fuel or chemical uses. In the example, the pronged sole-plate *D* has

Fig. 760.



Bog-Cutting Plow.

cutters attached beneath, and is followed by a mold-board *E* attached to the standard. A colter may be placed on the left prong of the sole-plate.

Bo'gie. (*Steam-Engine.*) A four-wheeled truck supporting the fore-part of a locomotive, and turning beneath it to some extent, if necessary.

Bo'gie-en'gine. (*Steam-Engine.*) A locomotive-engine employed at a railroad station in moving cars and making up trains. The driving-wheels and cylinders are on a truck which is free to turn on a center-pin.

Bo'gie-frame. (*Railroad Engineering.*) A four-wheeled truck, turning on a pivoted center, for supporting the front part of a locomotive-engine.

Bo-he'mi-an Glass. (*Glass.*) A clear crown glass, a silicate of potash and lime, a little of the silicate of alumina being substituted for the oxide of lead. The silica for this glass is obtained by pounding white quartz.

Boil'er. A vessel in which liquid is boiled.

1. Household-boilers are *kettles*, *saucepans*, and *clothes-boilers*.

2. The boiler for raising steam may be fairly called a *steam-generator*. See STEAM-BOILER.

3. The dyer's boiler is called a *copper*.

4. That of the sugar-worker is a *pan*.

5. That of the distiller, a *still*.

6. The chemist's boiler may be a *retort*, *alembic*, etc.

7. Lard and tallow rendering is performed in a *digester*, or *tank*.

The list below includes many of the different kinds of boilers — not the varieties of the kinds — and their parts. Most of them are described under their respective heads.

Agricultural boiler.
Air-heating boiler.
Bath-heater.
Blow-off pipe.
Boiler-alarm.
Boiler-feeder.
Boiler-float.
Boiler-prover.
Boiler-tube.
Brine-pump.
Brine-valve.
Caravan-boiler.
Cast-iron-boiler.
Coffee-boiler.
Cold-water boiler.
Cold-water pump.
Cornish boiler.
Culinary boiler.
Cylinder-boiler.
Detector, Low-water
Domestic boiler.
Egg-boiler.
Feeder, Boiler.
Feed-head.
Feed-pipe.
Feed-pump.
Feed-water apparatus.
Float.
Flue.
Flue-brush.
Flue-cleaner.
Flue-surface.
Foam-collector.
Fusible plug.
Gage-cock.
Gage-glass.
Generator, Steam
Giffard injector.
Heating surface.
High-pressure alarm.
Hot-water heating-apparatus.
Hot-water pump.
Hot-well.
Incrustation in boilers, Removing
Instantaneous generator.
Jacket.
Lagging.
Lard-boiler.
Lard-renderer.
Lock-up safety-valve.
Low-water alarm.
Low-water detector.
Low-water indicator.
Man-hole.
Mud-collector.
Mud-plug.
Mud-valve.
Multiflue-boiler.
Multitubular boiler.
Portable boiler and furnace.
Pressure-gage.
Priming-valve.
Safety-plug.
Safety-tube.
Safety-valve.
Salinometer.
Scale-borer.
Sectional steam-boiler.
Sediment-collector.
Skimmer.
Soap-boiler.
Steam-boiler.
Steam-boiler alarm.
Steam-cock.
Steam-coil.
Steamer.
Steam-gage.
Steam-generator.
Steam-heating apparatus.
Steam-jacket.
Steam-pressure gage.
Teakettle.
Tube.
Tube-brush.
Tube-cleaner.
Tube-cutter.
Tube-door.
Tube-expander.
Tube-fastener.
Tube-ferrule.
Tube-flue.
Tube-plate.
Tube-plate stay.
Tube-plug.
Tube-scaler.
Tube-sheet.
Tube-stopper.
Tubular boiler.
Wagon-boiler.
Wash-boiler.
Water-back.
Water-bridge.
Water-gage.
Water-heater.
Water-indicator.
Water-injector.
Water-leg.

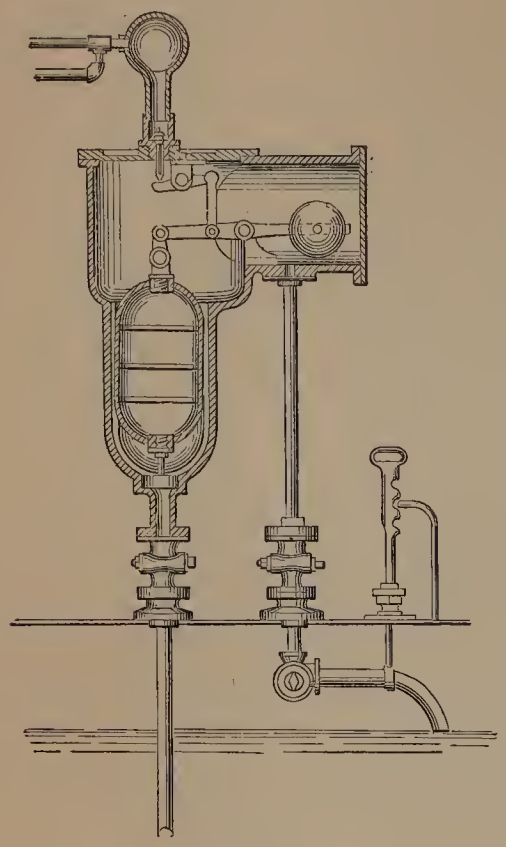
Boil'er-a-larm'. An apparatus or device for indicating a low stage of water in steam-boilers. See STEAM-BOILER ALARM; LOW-WATER ALARM.

Boil'er-feed'er. An arrangement, usually automatic and self-regulating, for supplying a boiler with water. The simple force-pump or injector, as worked by the engine or boiler, may or may not have self-regulating devices by which a nearly constant water-level is maintained, but there are other devices by which the variation in the water-level is made to bring into or withdraw the operative parts. See FEED-WATER APPARATUS.

One automatic arrangement is shown in Fig. 761. When steam is admitted through the short leg of

the siphon into the chamber above, the weight ceases to balance the float, and the latter, sinking, opens the water-supply, which ceases as the water rises in the

Fig. 761.



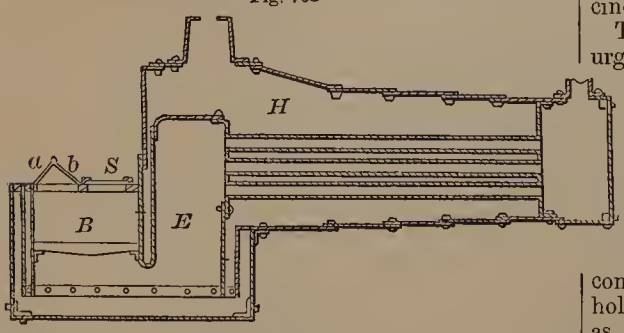
Boiler-Feeder.

boiler above the opening of the said leg of the siphon. The water-level in the boiler at which steam shall be so admitted is regulated by adjusting the said leg.

Boil'er-float. (*Steam-Engine.*) A float which rises and falls with the changing hight of water in a steam-boiler, and so turns off or on the feed-water.

Boil'er-fur'nace. (*Steam-Engine.*) One specifically adapted for the heating of a steam-generator. The shapes vary with those of the boilers themselves,

Fig. 762.



Boiler-Furnace.

the latter being cylindrical, wagon-shaped, vertical, etc. The illustration is an example of a downward draft-furnace, in which *a b* are the fuel-doors, *S* the draft-damper, *B* the furnace, *E* the fire-box, *H* the steam-space.

Boil'er-i'ron. Rolled iron of ¼ to ½ inch thickness, used for making steam-boilers, tanks, the skin of ships, etc.

Boil'er-pro-tect'or. A non-conducting covering to prevent the escape of heat. Among the devices for this purpose may be cited, —

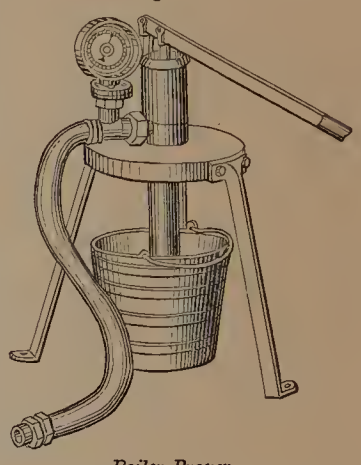
Felt, treated in various ways. *Asbestos.*

Lagging.

Allied to the above in position, if not in duty, are water-jackets to utilize the heat, air-flues and shields to protect surrounding bodies against the radiated heat.

Boil'er-prov'er. (*Hydraulics.*) A force-pump with pressure-indicator, used to try the power of a boiler to resist rupture under a given stress of hydraulic pressure.

Fig. 763.



Boiler-Prover.

Boil'er-stay. (*Steam-Engine.*) A tie-bar by which the flat plates on the opposite sides of boilers are connected, in order to enable them to resist internal pressure. The stays cross an intervening water or steam space.

Boil'er-tube. (*Steam-Engine.*) The tubes by which heat from the furnace is diffused through the mass of water in locomotive and other boilers of the smaller class. They are usually arranged longitudinally of the boiler, and are fitted by steam and water-tight connections to its heads. A *tube* carries water; a *flue* carries flame and the volatile products of combustion.

Boil'er-y. A *salt-house* or place where brine is evaporated.

Boil'ing-fur'nace. (*Metallurgy.*) A reverberatory furnace employed in the decarbonization of cast-iron to reduce it to the condition for mechanical treatment by hammer, squeezer, and rolls, by which it is brought into bar or plate iron. The term *boiling* refers to the bubbling which takes place during the process of conversion, and the word is somewhat local. This modification of the puddling-furnace was invented by Hall, and consists mainly in some differences in the proportion of the parts, the use of cinder, and of a greater heat.

The furnace is heated to an intense heat by a fire urged with a blast. The cast-iron sides are double, and a constant circulation of water is kept passing through the chamber thus made, in order to preserve the structure from fusion by the heat. The inside is lined with fire-brick covered with metallic ore and slag over the bottom and sides, and then, the oven being charged with the pigs of iron, the heat is let on. The pigs melt, and the oven is filled with molten iron. The puddler constantly stirs this mass with a bar let through a hole in the door, until the iron boils up or "ferments," as it is called. This ebullition is caused by the combustion of a portion of the carbon in the iron, and as soon as the excess of this is consumed, the cinders and slag separate from the semifluid mass, which the puddler stirs and forms into balls of such a size as he can conveniently handle, which are taken out and carried on ball-trolleys to the squeezer.

Bois-dur'ci. A compound of sawdust from hard

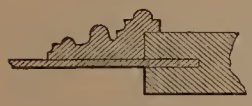
wood, such as rosewood or ebony, mixed with blood and other cementing material, and used to obtain medallions or other objects by pressure in molds.

Bo'las. A form of missile used by the Paraguay Indians, the Patagonians, and the Esquimaux. The *bolas* of the Patagonians has several varieties. That used in war consists of a single ball of hardened clay or rounded stone, weighing about a pound, and fastened to a stout rope of sinew or skin. This they sometimes throw at their adversary, rope and all, but generally they prefer to strike his head with it, like a slung-shot.

For hunting, they use two similar stones, fastened together by a rope, which is generally three or four yards long. One of the stones the hunter takes in his hand, and then, whirling the other round his head, throws both at the object he wishes to entangle. Sometimes several balls are used, but two is the usual number. They do not try to strike the object with the balls, but with the rope, and then, of course, the balls swing round in different directions, and the thongs are wrapped around the object. It is said that the natives can use the *bolas* effectually at eighty yards.

The *bolas* of the Esquimaux consists of a number of walrus teeth attached to the ends of strings whose other ends are united into a knot.

Fig. 764.



Bolection Molding

Bo-lec'tion. (*Joinery.*) Moldings surrounding the panels of a door, gate, etc., and which project beyond the general face of the same.

Bol'lard. (*Nautical.*) *a.* A large post or bitt on a wharf, dock, or on shipboard, for the attachment of a hawser or warp, in towing, docking, or warping.

b. A rundle in the bow of a whale-boat around which the line runs in veering; called also *logger-head.*

Bol'lard-tim'ber. (*Shipwrighting.*) A timber, one on each side of the bowsprit near the heel, to secure it laterally. A *knighthead.*

Bo-log'na-vi'al. (*Glass.*) A small unannealed vessel of glass, open at the upper end and rounded at the bottom end, which is thick. It will withstand a moderate blow on the bottom, but is cracked by dropping into it a small, angular piece of flint.

It is an example of the inherent strain and unstable static condition incident to unannealed glass. See ANNEALING.

Bol'ster. 1. (*Vehicle.*) The transverse bar over the axle of a wagon, which supports the bed, and into which are framed the standards which secure the bed laterally.

In the illustration, rubber springs are interposed between the axle and the bolster. Pistons beneath

Fig. 765.

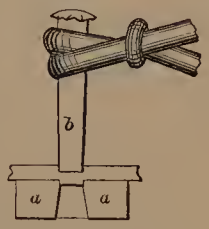
Wagon-Bolster.

the bed pass through the bolster and rest upon the springs, so as to give an elasticity to the bed up and down between the standards.

2. (*Machinery.*) *a.* A bed-tool *a* in a punching-machine. The perforated part on which a plate rests when the punch *b* drives out the *bur* or *planchet.* It has an opening of the same size and shape as the punch itself.

b. A perforated block of wood on which sheet-metal is laid for punching.

Fig. 766.



Bolster and Punch.

3. (*Music.*) The raised ridge which holds the tuning-pins of a piano.

4. (*Nautical.*) *a.* A piece of timber adjoining the hawse-hole, to prevent the chafing of the hawser against the cheeks of a ship's bow.

b. A cushion within the collar of a stay, to keep it from chafing on the mast.

c. A piece of wood or roll of canvas, upon which a rope rests, to keep it from chafing something or to give it a proper bearing.

5. (*Carpentry.*) *a.* A horizontal cap-piece laid upon the top of a post or pillar, to shorten the bearing of the beam of a string-piece above.

b. One of the transverse pieces of an arch centering, running from rib to rib and supporting the *voussoirs.*

6. (*Saddlery.*) A padded ridge on a saddle.

7. (*Ordnance.*) A block of wood fixed on the stock of a siege-gun carriage, on which the breech of the piece rests when it is shifted backward for transportation.

8. (*Railroad Engineering.*) The principal cross-beam of a railroad truck or car body.

9. (*Civil Engineering.*) The resting-place of a truss-bridge on its pier or abutment.

10. (*Cutlery.*) *a.* The shoulder of such instruments and tools as knives, chisels, etc., at the junction of the *tang* with the blade or the shank, as the case may be.

b. A metallic plate on the end of a pocket-knife handle.

11. (*Spinning-Machinery.*) The spindle-bearing in the rail of a spinning-frame. It forms a sleeve-bearing for the vertical spindle some distance above the lower bearing, which is called the *step.*

Bol'ster-plate. (*Vehicles.*) An iron plate on the under side of the bolster, to diminish the wear caused by its friction on the axle.

Bolt. 1. (*Machinery.*) A stout metallic pin, employed for holding objects together; frequently screw-threaded at one end to receive a nut.

Bolts may be divided into two principal classes, namely, those which are intended for fastening objects together permanently; and movable bolts, such as lock, sash, door, and gate bolts. Lock-bolts are usually operated by means of a key, while the last-mentioned are protruded and retracted by hand.

Bolts of the first class, — that is, for permanently fastening objects (and not mere sliding catches), may be distinguished, first, by their construction or mode of application; secondly, by their application.

As to construction, the difference may regard the shape of the head; as, *round, square, hexagon, octagon, sunk, countersunk-headed, clinch, collared, chamfered, diamond, convex,* etc.

Some structural peculiarity of the head; as, *eye, double-headed, hook, ring,* T-*headed,* etc.

The mode of securing; as, *screw, fox, forelock, clinch, rivet, ray, bay, barb, jag, key.*

As to the nature and purpose of their application they may be, — *assembling, fish, foundation, bringing-to, carriage, drive, fender, lewis, set, shackle, wagon-skein, tire, king, scarf, through,* etc.

The following list of bolts is approximately complete ; it includes other than *holding*-bolts.

Assembling-bolt.	Holding-down bolt.
Barbed bolt.	Hook-bolt.
Bay-bolt.	Jagged bolt.
Bringing-to bolt.	Key-bolt.
Carriage-bolt.	Lewis-bolt.
Clinch-bolt.	Pointed bolt.
Countersunk-headed bolt.	Rag-bolt.
Diamond-headed bolt.	Ring-bolt.
Door-bolt.	Riveted bolt.
Drive-bolt.	Rose-headed bolt.
Eye-bolt.	Round-headed bolt.
Fender-bolt.	Scarf-bolt.
Fish-bolt.	Screw-bolt.
Flour-bolt.	Set-bolt.
Flush-bolt.	Shackle-bolt.
Forelock-bolt.	Square-headed bolt.
Foundation-bolt.	Shingle-bolt.
Fox-bolt.	Tire-bolt.
Half-turning bolt.	Wagon-skein bolt.

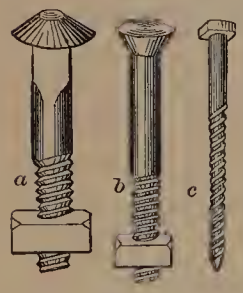
Assembling-bolt, one by which the separate portions of an object, made in detachable parts, are secured together ; as the assembling-bolt of a gun-carriage.

A *barbed* or *jagged* bolt has prongs projecting exteriorly and backwardly.

A *bay*-bolt is barbed to prevent retraction.

A *bringing-to* bolt has an eye at one end, and a nut and screw at the other. It is used in keying up.

Fig. 767.



Bolts.

Carriage-bolts are of various kinds for different parts of the work.

a, *carriage*-bolt.
b, *tire*-bolt.
c, *wagon-skein* bolt.

A *clinch*-bolt is one whose point is turned over by hammering.

A *countersunk-headed* bolt is one with a conical head to fill a countersink (3, Fig. 768 ; *b*, Fig. 767).

A *diamond-headed* bolt is one whose head is shaped like a rhomb or lozenge.

A *double-ended* bolt (5, Fig. 768) is used for holding together three objects independently of each other. It has a thread and nut on each end.

A *drive-bolt* is a tool used by shipwrights and other wood-workers for setting bolts, etc., *home ;* that is, *fixing* them, or giving them the last drive.

One used to expel another. A *drift.*

An *eye*-bolt or *eye-headed* bolt (6, Fig. 768) is used for securing a gland to a stuffing-box, or for other purposes, such as to receive a ring, lever, or rope.

A *fender*-bolt is one whose head projects so as to protect or fend off objects from the exposed surface which it unites to another.

A *fish*-bolt is one by which a *fish-bar* is fastened to a rail, as at the meeting-point of two railway rails.

A *flush*-bolt is one whose head is let down even with the surface (3, Fig. 768).

A *forelock* bolt is one having a slot in its end for receiving a key or cotter to prevent retraction.

A *foundation*-bolt is a long bolt holding a bed-plate down to the masonry or heavy framing substructure.

A *fox*-bolt is one with a split end into which a wedge is driven.

A *half-turning bolt* is one having a half-screw thread on one side and engaging in a similarly threaded socket. On pushing the bolt in and giving it a half-turn it becomes locked, and is unlocked by a corresponding reverse movement.

A *holding-down* bolt is similar to a foundation-bolt.

A *hook*-bolt is one with a hook-head.

A *jagged* bolt has barbs to the shank.

A *key*-bolt is secured by a cotter or wedge passing through a slot in the shank. Such an one is used in shipbuilding for securing the false keel. A *forelock* bolt.

A *lewis* bolt (7, Fig. 768) is used for fixing on to a block of stone ; for this purpose a hole is cut in the stone large enough at the top to admit the thick end of the wedge-shaped bolt, which is barbed at the angles and run with lead.

The *pointed* bolt is a round bolt with an end that may be clinched.

A *rag*-bolt is one having a jagged end to prevent its being drawn out from timber, etc.

A *ring*-bolt is one which has an eye for receiving a ring.

A *rivcted* bolt is one whose point end is battered and upset.

A *rose-headed* bolt is one whose head forms part of a sphere. The resemblance to the *rose* is very remote (4, Fig. 768).

A *round-headed* bolt has a head cylindrical or formed as a segment of a sphere.

A *scarf*-bolt is a shipbuilder's bolt used for securing the false keel.

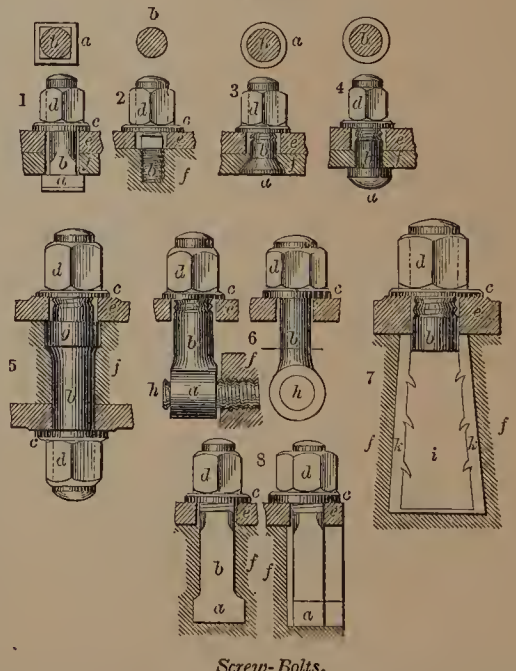
A *screw*-bolt is one having a screw-thread on the whole or a considerable portion of its length.

Bolts of bronze were used in ancient Egypt, but had no thread. One in Dr. Abbott's collection has the square head for turning.

There are many kinds.

1 is a *screw*-bolt having a square head *a*, a short round shank *b*, washer *c*, and nut *d ;* by this screw-bolt the pieces *e f* are fastened together.

Fig. 768.



Screw-Bolts.

2 shows a *screw*-bolt in which the latter is tapped with the object *f*, and the portion *e* tightly fastened down thereon by the nut *d*.

3 has a *countersunk*-head which sinks into the body of *f* so as to become flush with the surface of the latter.

4 is a *round-headed* bolt which has a lip to prevent turning when the nut is screwed on or off.

5 is a *double-headed* bolt which has a nut on each end, and by which two pieces *e e* are secured to the portion *f*, whose recess holds the collar *g* of the bolt.

6 shows two views of an *eye*-bolt, represented as fastening a gland to a stuffing-box.

7 is a *lewis*-bolt whose barbed shank *i* is surrounded by lead *k* poured into the under-cut mortise in the block *f*.

8 shows two views of a T-headed bolt, to fasten a plate accessible only from one side.

A *set*-bolt is one used by shipwrights in closing up the planks.

A *shackle*-bolt is one having an eye for the insertion of a clevis, which is held by a pin and key.

The *square-headed* bolt has a quadrilateral head adapted to be grasped by a wrench.

The T-*headed* bolt is used to fasten against a plate which is only accessible from one side. In this case a slotted hole is made in the plate, of the size of the T head of the bolt, which is then passed through and turned round at right angles to the hole.

A *through*-bolt is one which goes *through* the pieces which are to be fastened together. Such are clinch-bolts, and bolts secured by nut and washer.

A *tire*-bolt is an ordinary nut and washer bolt, used for securing tires to the fellies of wheels. The nut and washer are applied on the interior of the felly, and the head countersunk into the tire. See *b*, Fig. 767.

A *wagon-skein* bolt is a peculiarly shaped bolt without a nut, and is used for fastening the skeins to the spindles of wagon-axles. (See *e*, Fig. 767.)

Rule for the computation of the weight of bolts: —

Wrought-iron: square the radius of the bolt, and multiply it by 10, the product will give the weight in pounds per foot.

Cast-iron: subtract from the above result $\frac{2}{27}$, or .074 of the result. — HORATIO ALLEN.

The following standard for screw-threads, bolt-heads, and nuts has been adopted by the United American Railway Master Car-Builders' Association: —

Diameter of Bolt.	Number of Threads per Inch.	Diameter of Bolt.	Number of Threads per Inch.
$\frac{1}{4}$	20	2	$4\frac{1}{2}$
$\frac{5}{16}$	18	$2\frac{1}{4}$	$4\frac{1}{2}$
$\frac{3}{8}$	16	$2\frac{1}{2}$	4
$\frac{7}{16}$	14	$2\frac{3}{4}$	4
$\frac{1}{2}$	13	3	$3\frac{1}{2}$
$\frac{9}{16}$	12	$3\frac{1}{4}$	$3\frac{1}{2}$
$\frac{5}{8}$	11	$3\frac{1}{2}$	$3\frac{1}{4}$
$\frac{3}{4}$	10	$3\frac{3}{4}$	3
$\frac{7}{8}$	9	4	3
1	8	$4\frac{1}{4}$	$2\frac{7}{8}$
$1\frac{1}{8}$	7	$4\frac{1}{2}$	$2\frac{3}{4}$
$1\frac{1}{4}$	7	$4\frac{3}{4}$	$2\frac{5}{8}$
$1\frac{3}{8}$	6	5	$2\frac{1}{2}$
$1\frac{1}{2}$	6	$5\frac{1}{4}$	$2\frac{1}{2}$
$1\frac{5}{8}$	$5\frac{1}{2}$	$5\frac{1}{2}$	$2\frac{3}{8}$
$1\frac{3}{4}$	5	$5\frac{1}{4}$	$2\frac{3}{8}$
$1\frac{7}{8}$	5	6	$2\frac{1}{4}$

The distance between the parallel sides of a bolt-head and a nut for a rough bolt shall be equal to one and a half diameters of the bolt plus one eighth of an inch.

The thickness of the heads for rough bolts shall be equal to one half the distance between their parallel sides.

The thickness of the nut shall be equal to the diameter of the bolt. The thickness of the head for a finished bolt shall be equal to the thickness of the nut.

The distance between the parallel sides of a bolt-head and nut, and the thickness of the nut, shall be one sixteenth of an inch less for finished work than for rough.

2. (*Locksmithing.*) That portion of a lock which is protruded beyond or retracted within the case or boxing by the action of the key, and which engages with the keeper or jamb to form a fastening.

The thick protruding portion is the *bolt-head*, and the flat part within the lock is the *bolt-plate*.

3. (*Household Hardware.*) A movable bar protruded or retracted by hand to fasten or release a door, gate, window-sash, etc. It is usually affixed to the movable object, and is received into a staple, box, or perforated plate attached to the post, jamb, or style, as the case may be.

Bolts are distinguished by

Shape; as, *square*, *round* (*e*), *flat* (*a*), *barrel* (*e*), etc.

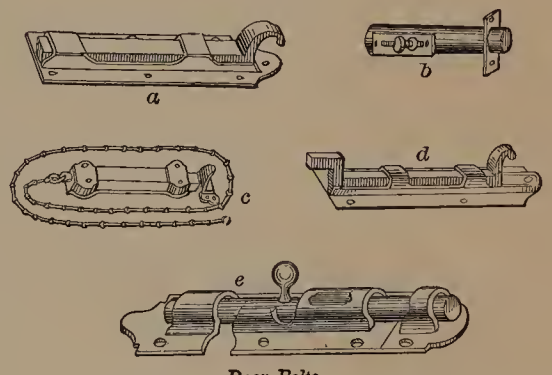
Purpose; as, *shutter*, *sash*, etc.

Construction; as, *chain* (*c*), *spring mortise* (*b*), *necked* (*d*), *dormant*, *catch*, *flush*, *drop*, etc.

Or by mere trade-names; as, *cottage*, *tower*, etc.

Some of the names are synonyms.

Fig 769.



Door Bolts.

4. (*Milling.*) A sieve of very fine stuff, for separating the bran and coarser particles from flour. See FLOUR-BOLT.

5. (*Wood-working.*) *a.* A rough block from which articles are to be made; as, a *bolt* for riving into shingles, spokes, etc.

b. A number of boards adhering together by the *stub-shot*.

6. (*Fabric.*) A piece or roll of cloth.

A bolt of canvas is about 40 yards long, and the stuff is from 22 to 30 inches wide.

7. (*Nautical.*) The iron rod beneath a yard, to which a square sail is attached.

8. (*Ordnance.*) An elongated solid projectile for rifled cannon, as the Whitworth and Armstrong guns.

9. (*Bookbinding.*) The fold in the fore-edge and head of a folded sheet.

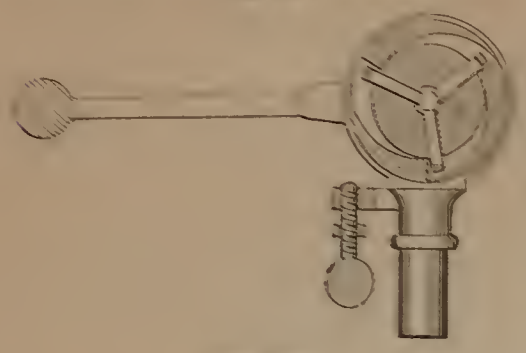
Bolt-au'ger. An auger used by shipwrights in sinking holes for bolts.

Bolt-chis'el. (*Machinery.*) A cold chisel for cutting off the extra length of a bolt. A cross-cut chisel. A deep chisel with a narrow edge.

Bolt-cut'ter. (*Machinery.*) *a.* A tool for cutting off bolts. It usually consists of a sleeve with a radial cutter setting inwardly and rotated around the

bolt to be cut by means of a handle. In the example, the circular cutter-holder or hub is supported

Fig. 770.



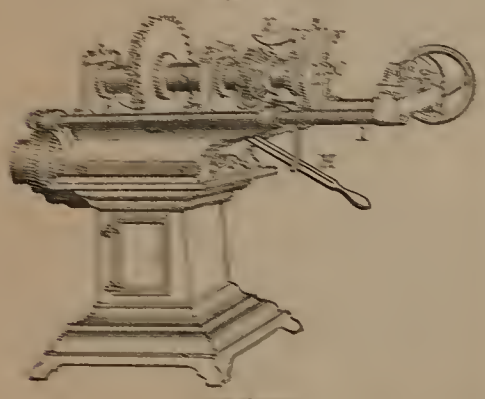
Bolt-Cutter.

and partly inclosed by a thick ring with inwardly projecting flanges at the edges. The inner surface of this ring is divided into three sections, each of equal eccentricity to the hub, and against which the outer ends of the cutters abut: these are adjustable to or from the center, by rotating the hub in the proper direction by means of a handle attached thereto, the extent of whose motion is controlled by an adjustable stop formed by a set screw passing through an arm projecting from the standard on which the tool is supported.

2. A machine for cutting the thread on bolts. It consists of a framing *A* in which the revolving mandrel *B* works. This has the dies at one end *C*, which are operated as follows.

When the machine is started, the cone *D* is shipped up so that the ends of the levers *E*, resting on it, are raised. These levers being fastened, or

Fig. 771.



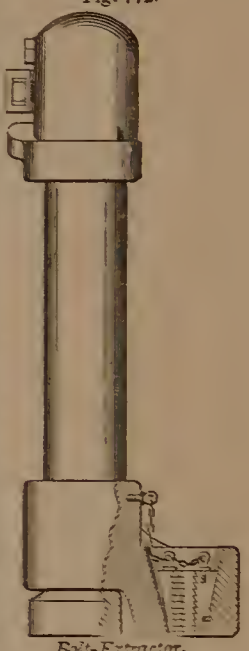
Bolt-Cutter.

having a fulcrum on the die-plate, depress the dies so that they may engage with the bolt to be cut: this is held between the jaws *F*, operated by the hand-wheel *G*. As soon as the bolt is cut, the handle *H*, when lifted, disengages the dies from the bolt, so that it can be taken back without running on the thread, thus saving time and avoiding injury. The mandrel *B* is hollow, and allows the bolt to enter it while the carriage is drawn along with the guides *I*.

The bolt-thread cutter adapted to the uses of the machinist is known as the *screw and dies*. Similar tools are used by gas-fitters, plumbers, and steam-fitters in threading the ends of the welded iron tubes now so much used in fitting houses with "all the modern conveniences." Some of these tools are made with two shanks like tongs, others with a stationary and a sliding jaw like a wrench.

Bolt-ex-tract'or. A tool or implement for extracting bolts by a lifting force. In the example, the hydraulic jack has a foot which has wedge-shaped jaws sliding in inclined slots within a cavity, whereby a great force may be applied in an advantageous manner, the line of draft being directly in the line of the axis of the bolt. The jaws have barbs to increase their grip on the bolt.

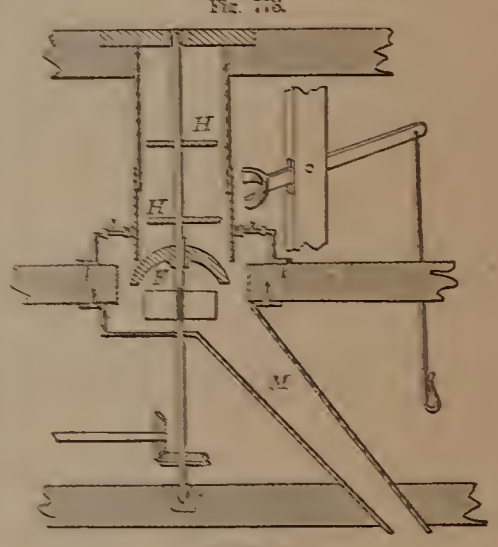
Fig. 772.



Bolt-Extractor.

Bolt-feed'er. (*Milling.*) A device for regulating the rate of passage of the meal to the flour-bolt. In the example, the meal is subjected in the cylindrical case to the action of the radial arms *H* of the rotating shaft. This shaft bears the saucer-shaped disk *F*, which stops the lower end of the cylinder. The lower section of the cylinder slides on the upper, and regulates the size of the annular exit-opening leading to the ventilating case containing the fan. From this case it passes to the chute *M*.

Fig. 773.

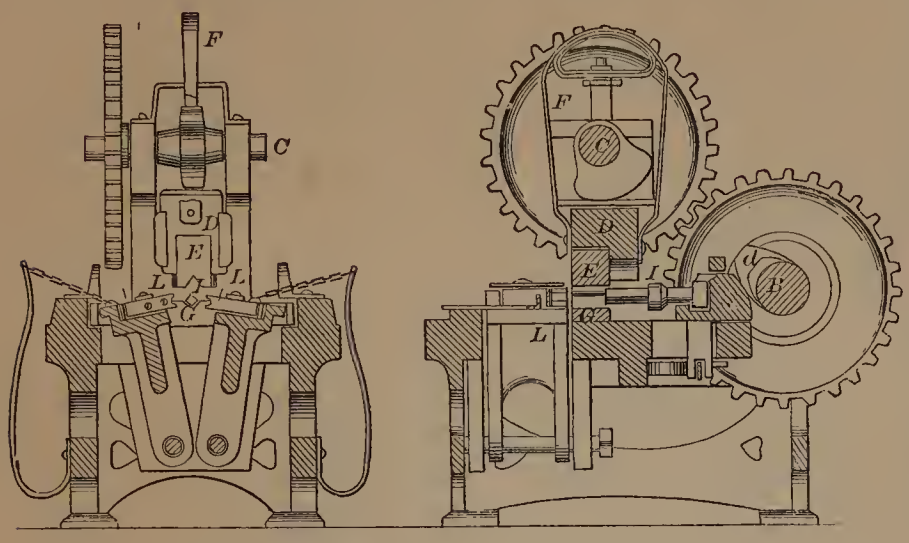


Bolt-Feeder.

Bolt-head. (*Glass.*) A long glass matrass or receiver with a straight neck.

Bolt-head'er. (*Machinery.*) A machine for swaging down the end of a bolt-blank to form a head: the form of this depends upon that of the die. In the example, the swinging holders *I I* cause the cutter to produce a drawing cut, and are made to move simultaneously with the die toward the bar, when the front end of the blank is cut off. The separated blank is then held by the holders, and its rear end is between the stationary die *G* and the reciprocating die *E*, when the punch *I* moves forward and heads the same. The holders and dies are then simultaneously drawn apart, and the finished bolt is released. The die *E*, in the holder *D*, is reciprocated by the cam or shaft *C*, and the recoil spring *F*; the punch is actuated by the cam *d* on the shaft *B*.

Fig. 774.



Bolt-Heading Machine.

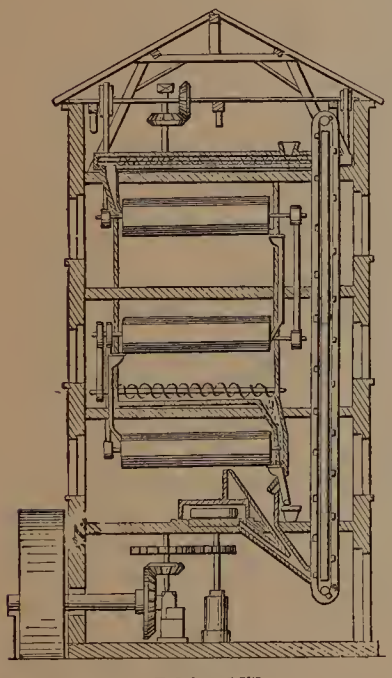
Bolt'ing-cloth. (*Milling.*) Cloth of hair or other substance with meshes of various sizes for sieves.

Bolt'ing-chest. (*Milling.*) The inclosure or case of a flouring-bolt.

Bolt'ing-hutch. (*Milling.*) A tub or box into which flour or meal is bolted.

Bolt'ing-mill. (*Milling.*) A machine in which flour is separated from the offal of various grades. The meal from the stones is passed through cylindrical sieves having meshes of varying degrees of fineness, at different parts of its length or through various sieves. In the illustration the several stones of the mill are shown; the meal from the stones passing down to the well of the elevator, which raises it to the upper bolt, from which it passes downward to others in succession.

Fig. 775



Bolting-Mill.

Bolt-mak'ing Ma-chine'. (*Machinery.*) One in which bolts are threaded and headed, though this is usually done in separate machines, as the threading is done by cutters on the cold iron; heading by swaging upon the end of the hot blank. See BOLT-HEADER; BOLT-THREADER.

Bolt-rope. (*Nautical.*) A rope around the margin of a sail to strengthen it. It is

A *leech-rope*, up the sides.

A *head-rope*, along the top.

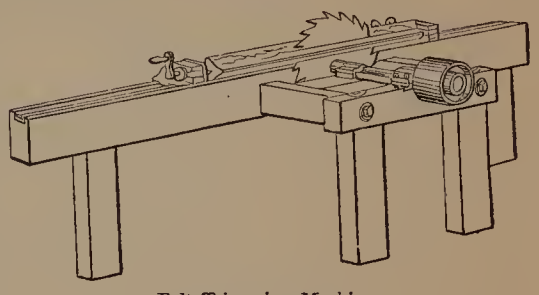
A *foot-rope*, at the bottom.

The *cringles* for bending-on the sail, and for the attachment of the reef-tackle, are worked in and around the *bolt-ropes*. See SAIL.

Bolt-rope Nee'dle. (*Nautical.*) A strong needle for sewing a sail to its bolt-rope.

Bolt-saw'ing Ma-chine'. (*Wood-working.*) For sawing superfluous wood, such as corners, from stuff to be turned. It has an iron carriage with centers between which the work is chucked while being fed to the circular saw. (Fig. 776.)

Fig. 776



Bolt-Trimming Machine.

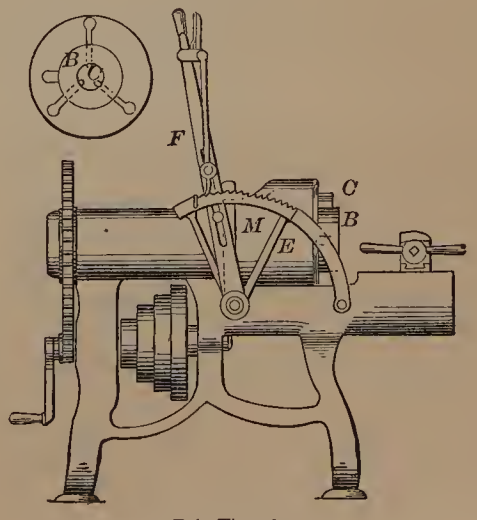
Bolt-screw'ing Ma-chine'. A machine for cutting screw-threads on bolts, by fixing the bolt-head to a revolving chuck, and causing the end which it is required to screw to enter a set of dies, which advance as the bolt revolves. A *bolt-threader*.

Bolt-sprit. (*Nautical.*) Another, now disused, name for BOWSPRIT (which see).

Bolt-strake. (*Shipbuilding.*) That strake or wale through which the beam-fastenings pass.

Bolt-thread'er. (*Machinery.*) A machine for cutting screw-threads on bolts. In that shown in Fig. 777, the head *E*, containing the cutters *C*, sur-

Fig. 777.

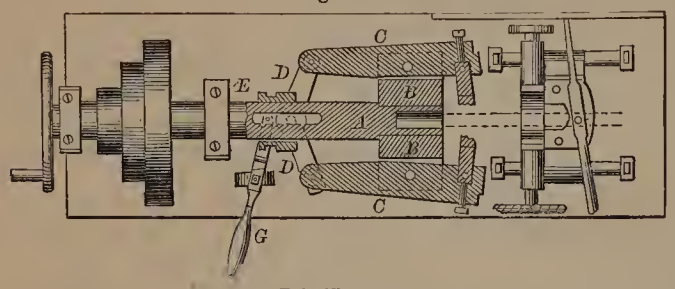


Bolt-Threader.

rounds the hollow mandrel *B*, and is reciprocated by means of the lever *F*, moving along the graduated arc *M*. As the head *E* is advanced, the fixed bolt enters the bore of the mandrel, and is threaded by the cutters *C*. The cutter-head may be rotated by hand or otherwise.

In Fig. 778, the bolt-head enters a rectangular recess in the longitudinally sliding stock. The dies are secured to jaws *C C* pivoted to the tubular spindle *B* of the head-stock. The forward ends of the jaws are brought together by toggle-levers at their rear ends. The toggle-levers *D D* are pivoted to a circumferentially grooved collar *E*, turning with the mandrel *A*, but slid thereon by a hand-lever *G*.

Fig. 778.



Bolt-Threader.

Bomb. (*Ordnance.*) A spherical hollow shot, fired from a *mortar* or *howitzer*, and filled with explosive material which is lighted by a *time* or *percussion fuse*.

Bombs were used at the siege of Naples in 1434. Mortars for bombs were cast at Buckstead, England, 1543. See SHELL.

Bom'bard. (*Ordnance.*) An ancient mortar of large bore, used to throw stone shot.

Bom'bar-do. (*Music.*) A wind-instrument like a bassoon, and used as a base for the oboe.

Bom'ba-zine. (*Fabric.*) A mixed silk and woolen twilled stuff. The warp is silk and the weft worsted.

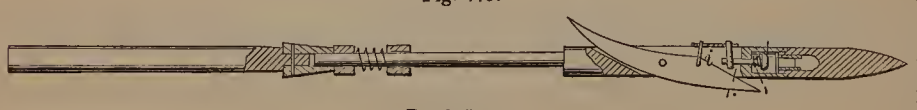
Bomb-chest. A box filled with explosive projectiles or materials, and buried in the earth, in military mining.

Bomb-ketch. (*Vessels.*) A small, strongly built vessel, keteh-rigged, on which one or more mortars are mounted for naval bombardments.

Mortar-vessels are said to have been iuvented by Reyneau, and to have been first used at the siege of Algiers in 1682.

Bomb-lance. A harpoon which carries a charge of explosive material in its head. In the example, the head is charged with powder, and when the harpoon penetrates the fish, the bar which is pivoted obliquely in the head serves to release the spring-actuated hammer, which explodes the cap and bursts the charge-chamber.

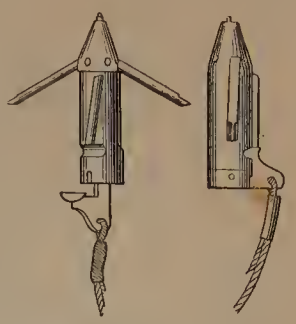
Fig. 779.



Bomb-Lance.

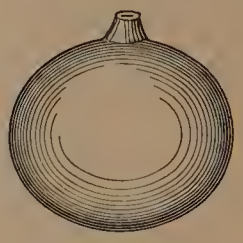
A form of bomb-lance which has been very successful is shown in Fig. 780. It is a cast-iron tube about 12 inches long and 1 inch diameter, carrying in a charge-chamber 100 grains of gunpowder. It is fired from a gun, and the match is lighted in the act of firing. Prongs fly out from the tube to prevent retraction of the missile.

Fig. 780.



Harpoon-Ball, or Bomb-Lance.

Fig. 781.

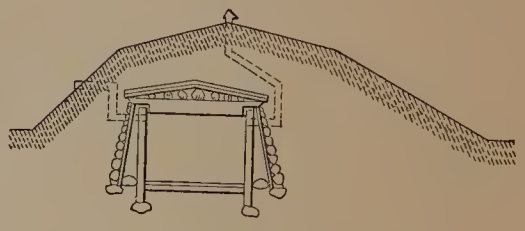


Bombolo.

Bom'bo-lo. (*Glass.*) A spheroidal retort in which camphor is sublimed. It is made of thin flint-glass, weighs about one pound, and is 12 inches in diameter. It is heated in a sand-bath to 250° Fah., which is gradually increased to 400°. For the details of the operation, see URE; CAMPHOR.

Bomb-proof. (*Fortification.*) A structure in a fortification which is so covered with earth as to be secure from the penetration of cannon-balls by the ordinary or plunging fire. It may be a structure of stone, brick, or wood, but must have strength to bear a heavy load of earth, which converts it into a mound in which shot are buried without penetrating to the interior.

Fig. 782.



Bomb-Proof.

Bomb-shell. A spherical or cylindrical case of iron loaded with powder, and burst by its charge on concussion or after an interval of time. See SHELL.

Bo-na-ven'ture-miz'zen. An additional or second mizzen-mast, formerly used in some large ships.

Bond. That part or those parts of a built structure which tie the other portions together.

1. (*Masonry.*) A stone or brick which is laid with its length across a wall, or extends through the facing course into that behind, so as to bind the facing to the backing. Also known as *binders; bond-stones; binding-stones; through-stones; perpend-stones, header.*

Perpend signifies that a heading-stone passes through the whole thickness of a wall.

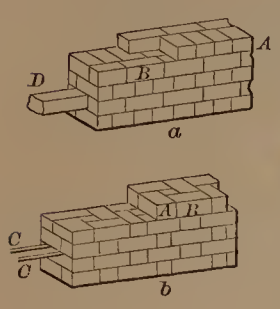
Binder, that it extends a part of the distance across.

Heart-bond, in stone-walling. In this there are no perpend-stones, but two headers meet in the middle of the wall, and the joint between them is covered by another header.

Chain-bond is the building into the masonry of an iron chain or bar, or heavy scantling.

Cross-bond. A block-bond in which the joints of the second stretcher-course come in the middle of the first; a course of header and stretcher intervening. See *c*, Fig. 783.

Fig. 783.



Wall-Bonds.

Block and cross bond. The extrados of the wall is put up in *cross-bond;* the intrados in *block-bond.*

2. (*Bricklaying.*) A particular mode of disposing bricks in a wall so as to tie and break joint.

The *English bond* (*a*) has courses of headers alternating with courses of stretchers.

In the *Flemish bond* (*b*) each course has stretchers and headers alternately.

A, *header.*
B, *stretcher.*
C, bond of hoop-iron.
D, timber-bond.

3. (*Roofing.*) The distance which the tail of a shingle or slate overlaps the head of the second course below. A slate 27 inches long, and having a *margin* of 12 inches *gage* exposed to the weather, will have 3 inches *bond*, or *lap*. The excess over twice the *gage* is the *bond.*

4. (*Carpentry.*) Tie-timbers placed in the walls of a building; as bond-timbers, lintels, and wall-plates.

Bond-pa'per. A thin, uncalendered paper made of superior stock, and used for printing bonds and similar evidences of value.

Bond-stone. (*Masonry.*) A stretcher used in uncoursed rubble-work; if inserted the whole thickness of the masonry, it is called a *perpend* or perpend-stone.

Bond-tim'ber. (*Bricklaying.*) One put lengthwise into a wall to bind the brickwork together, and distribute the pressure of the superincumbent weight more equally. It also affords hold for the battens, which serve as a foundation for interior finishing.

Bone. 1. (*Surveying.*) To sight along an object or set of objects to see if it or they be level or in line.

2. Physiologically speaking, the material of the skeleton or framework of the body.

Chemically considered, a compound of animal and earthy matters, the latter giving rigidity to the cellular tissue.

Mechanically considered, the uses of bone are for turning, inlaying, handles of knives and tools, billiard balls, scales, etc. The term includes the ordinary bones of the body, and also the tusks and teeth of the elephant, hippopotamus, walrus, and whale.

Bone is also, when deprived of its animal matters by distillation, used as a defecating, bleaching, and filtering material in the treatment of sirups and distilled liquors, and in the purification of water. Bone-black is also used as a pigment in making printer's ink.

Bone, while yet fresh, is used by pastry-cooks to prepare a clear and rigid jelly.

Bone is used by steel-workers as a carbon in the hardening of steel.

Whalebone (so called) is not a bone, but partakes of the nature of horn. See BALEEN.

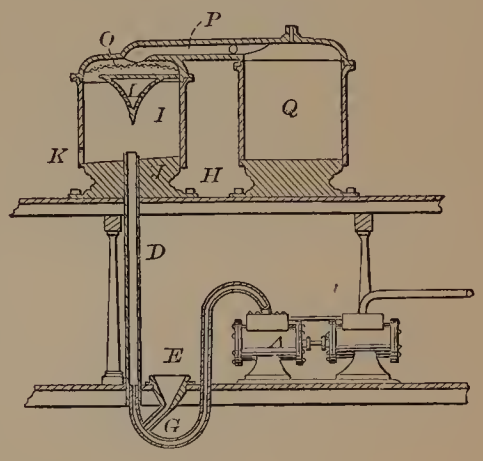
Bone is used by husbandmen as a manure.

Bones blanched in an open fire, removing the carbon, yield a powder which is used in making the cupels of the assayer, in making phosphorus, and as a polishing material.

Bone-black. Produced by calcining the bones or ivory of animals in close vessels. This process leaves the animal charcoal, consisting of the earthy and saline portions of the bone, combined with carbon, while the volatile matters are distilled over. Among these products is a peculiar oil, which is burned in lamps in close chambers; the soot which accumulates on the sides is collected, and forms the pigment known as bone-black or ivory-black, according to quality.

Bone-black Clean'ing-ap'pa-ra'tus. A device for purifying, screening, and cooling bone-black after treatment in the revivifying retort. In Hanford's apparatus the hot bone-black from the furnace

Fig 784.



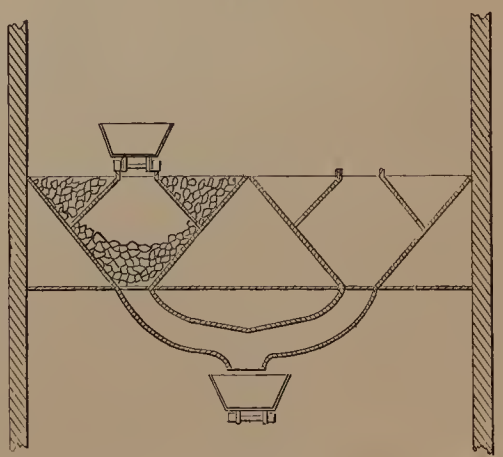
Hanford's Bone-Black Cleaner.

is received in a hopper *E*, driven by force of air from the pump *A* through the pipe *D*, is received in a closed chest *I*, having an inverted conical perforated deflector *L*, which directs the larger masses downward, where they are discharged by the slanting floor and opening *K*. The smaller particles and dust are carried by the blast of air through the openings in the conical screen *L*, the second screen *O*, and the pipe *P*, to the next chamber *Q*. A jet of steam is injected into the pipe *P*, so as to damp the dust in passing and assist in its deposition.

Bone-black Cool'er. An apparatus for cooling animal charcoal after its removal from the furnace.

The hot, reburnt coal is poured into hoppers, passed through an annular opening, and then through pipes into a car. The plates against which it passes

Fig. 785.



Bone-Black Cooler.

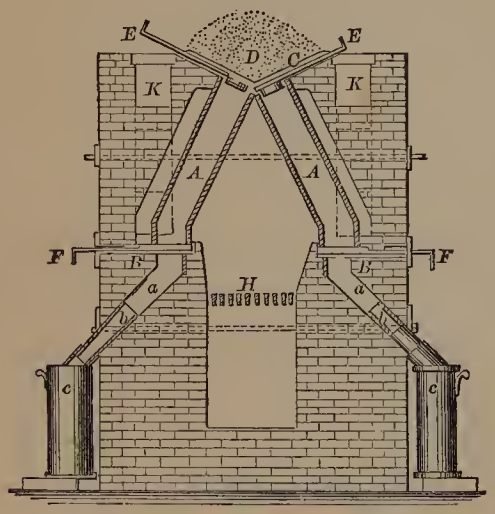
are kept cool by a current of cold air through a surrounding channel. The tops of the plates may be arranged so as to form a railroad-car track, over which trucks containing the hot coal may travel.

Bone-black Fur'nace. No material equal to bone-black has yet been discovered for decolorizing and purifying saccharine solutions. After a certain quantity of sirup has been filtered through it, it is necessary to revive it by removing the gum, sugar, and other vegetable extract that has filled its pores and deprived it of its useful qualities. Some of these matters, such as gluten, are not soluble in water until after fermentation, or an equivalent chemical treatment. The practice has been to suffer the bone-black to ferment in a heap, to decompose the organic matter, after which it is washed, dried, and recalcined, acquiring again its full decolorizing powers, but having lost a portion, due to the crumbling in the various processes through which it is passed. This is calculated by Fleischman to be from 12 to 15 per cent per annum; by an English author, to be 6 per cent on each turning; and by a writer in Harper, who has studied the economy of the Cuban systems, at 10 per cent for each use, which is probably an extreme calculation. Much depends upon the system adopted in its revivification. This is done in several ways: —

1. Calcination in iron pots.
2. Calcination in retorts; horizontal or vertical.
3. Purging by highly heated steam.
4. Roasting in open revolving-cylinders.
5. Washing in dilute hydrochloric acid.
6. Washing in a dilute lye of potash or soda.

Fig. 786 shows one form of furnace for revivifying bone-black, in which the bone-black *D*, charged with impurities, is deposited in the hopper *C*, where the withdrawal of slides *E* permits it to fall into the tubes *A A*, which are exposed to the heat from the furnace-

Fig. 786.

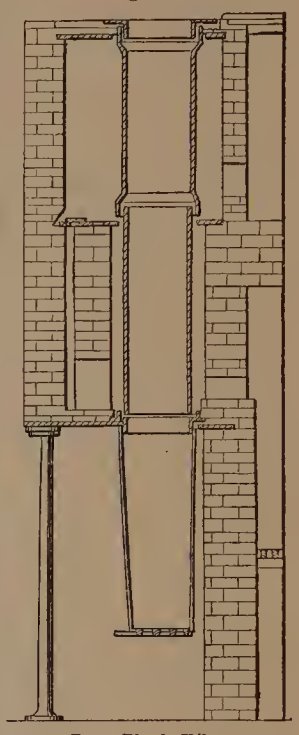


Bone-Black Furnace.

grate *H* until the impurities are discharged, when, by withdrawing the slides *F F* on the bottom-plates *B B*, it passes into the tubes *a a b b*, and is received into the vessels *c c*. *K K* are flues for conducting off the products of combustion and partially drying the black before it is admitted to the tubes *A A*.

Bone-black Kiln. A chamber or retort mounted in a furnace for re-burning bone-black to remove impurities with which it has become saturated or impregnated during its use as a defecator and filtering-material. Eastwick's bone-black kiln has a retort in three lengths, each supported separately, so as to prevent the weight of the whole column from bending the lower section when heated to redness. The upper section is the receiving; the middle section has the greatest heat; the lower section is not immediately affected by the fire, and forms the cooler. At the foot of the latter is a draw-damper for discharge.

Fig. 787.



Bone-Black Kiln.

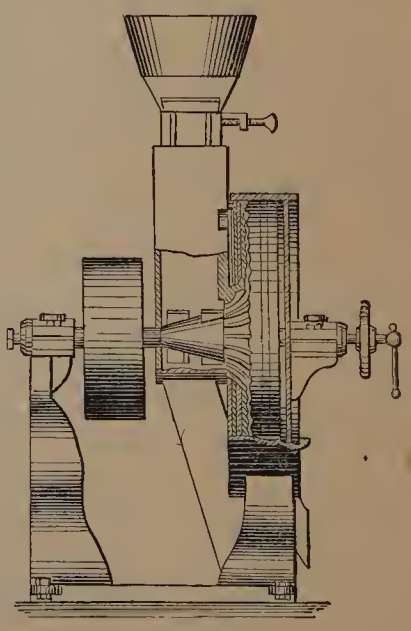
Bone-el'-e-va'tor. (*Surgical.*) A lever for raising a depressed portion of bone, as a part of the cranium, for instance.

The boys' "sucker," a wet disk of leather applied to the part and then raised by a string in the center, has been suggested for raising depressed portions of fractured skulls. Ewbank humorously suggests that it might be used to cause a development of the finer organs of the brain by application over those phrenological regions deserving of encouragement. In this, however, Nicodemus Easy was considerably ahead of Mr. Ewbank, for the old gentleman had a complex machine where suction and pressure had each its part to play in raising the finer sentiments and depressing the baser organs. See Marryat's "Midshipman Easy."

Bone-mill. A machine for grinding bones for fertilizer or for making bone-black.

Bone-grinding is effected by passing the bones through a series of toothed rollers arranged in pairs, the rollers being toothed or serrated in different degrees of fineness, and riddles are provided for sifting the bones into sizes, and they are then sold as inch, three-quarters, half-inch, and dust.

Fig. 788.



Bone-Mill.

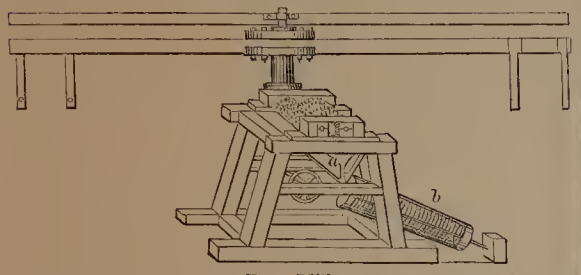
The mill shown in Fig. 788 is made of iron, and is bolted to a foundation. Bones placed in the hopper fall through the chute, and are broken by a crusher at its bottom. They thence pass between a stationary grinding-plate and a revolving grinding-

plate *B C*, turned by the axis and pulley *E*, faced with hollowing diamond-shaped projections arranged in lines radiating from the center. While these are dulled at one edge by constantly turning the mill in one direction, they are sharpened at the other, and the motion of the mill is reversed, bringing the latter into action. The plate *B C* is adjusted to grind to any degree of fineness, by means of the screw-wheel and hand-lever shown at *A*.

An English bone-mill has a pair of rollers with circular, square-edged grooves, like those of a rolling-mill, the salient faces of the teeth being serrated and meshing with those of the opposite roll. The plumber-block of one roll is adjustable, so as to vary the distance between the rolls for large or small bones.

The machine is driven by two horses attached to the sweeps, and the bones are passed through several

Fig. 789.



Bone-Mill.

times, the rolls being set up a little each time by means of set screws. The bones, after passing between the rolls, are conducted by the hopper *a* into a revolving screen *b*, which is driven by a bevel-wheel working into a pinion on the screw-shaft.

"Hadrian (whose bones may they be ground and his name blotted out!) [he had rebuilt Jerusalem under the name Ælia Capitolina, dedicated it to Jupiter, and forbade a Jew to enter the city under pain of death] asked Rabbi Joshua Ben Hannaiah, 'How doth a man revive again in the world to come?' He answered and said, 'From *Luz*, in the backbone.' Saith he to him, 'Demonstrate this to me.' Then he took *Luz*, a little bone out of the backbone, and put it in water, and it was not steeped; he put it into fire, and it was not burnt; he brought it to the mill, and that could not grind it; he laid it on the anvil and knocked it with a hammer, but the anvil was cleft and the hammer broken."

Bones. (*Music.*) A musical instrument, if it may be so called, by which the rhythmical beat of a tune is maintained in the manner of castanets. The name is derived from the material originally used. A pair of bones or small wooden maces is held in the hand and separated by a finger, so that the protruding ends may tap against each other, and give a sharp snapping sound. The raps are governed by the play of the hand.

The *bones* are the usual accompaniment of the sable harmonists, and the instrument is popularly supposed to be of negro origin. It is a legitimate African tinkler, having been used in ancient Egypt as far back as the prosperous Theban era. Round-headed pegs (*crotala*) were held between the fingers of the dancers in the festivities of Herculaneum, and used after the manner of the modern *boncs* by rattling in the hand. The maces of the ancient Egyptians were metallic and sonorous; those of the Japanese are of wood. The effect desired is or was substantially the same in the cases cited. A sharp snap to beat the measure, audible above the hum of the people, the rub-a-dub of the little drums, the clapping of hands, the twanging of the stringed and whistling of the wind instruments. *Castanets, maces, sonnettes, cymbals*, are different forms of striking instruments. See CASTANETS; DRUM.

Bon-grace. (*Nautical.*) A bow-grace or junk-fender.

Bon'ing. (*Surveying.*) The operation of leveling by means of the eye.

Bon'ing-stick. (*Building.*) A stick with a head like the letter T, to indicate a level for work or construction. A number of such sticks over a site indicate a certain level for the tops of base pieces or foundation-blocks.

Boning, in carpentry or masonry, is performed by placing two straight edges on an object and sighting on their upper edges to see if they range. If they do not, the surface is said to be *in wind*.

Bon'net. 1. (*Wear.*) A lady's head-gear, having a crown and a curved brim displayed upward and forward.

2. (*Fort.*) A portion of a parapet elevated to a traverse to intercept enfilade fire.

3. (*Machinery.*) *a*. A cast-iron plate covering the openings in the valve-chamber of a pump, and removable for the examination and repair of the valve and seat.

b. A metallic canopy or projection, as of a fireplace or chimney. A cowl or wind-cap. A hood for ventilation, or the smoke-pipe on a railway-car roof.

c. The dome-shaped wire spark-arresting cover of a locomotive chimney.

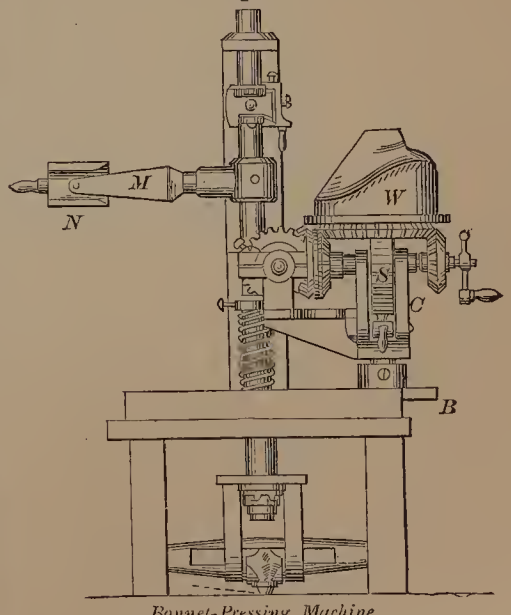
4. A sliding lid for a hole in an iron pipe.

5. (*Nautical.*) An additional piece of sail added by lacings to the foot of a jib, or a schooner's fore-sail. It is used during light winds.

Bon'net de Prêtre. (*Fortification.*) Called also priest's cap or swallow-tail. A *double redan*. See REDAN.

Bon'net-shap'ing Ma-chine'. A machine in which a partially shaped bonnet is pressed down upon a forming-block, to give it a set shape. One die has the exterior, the other the interior shape; one is usually heated so as to dry the bonnet and make it rigid in its acquired form. The process and machine are similar to the hat-forming machine, the difference being principally in the shape of the article. See HAT-FORMING MACHINE.

Fig. 790.



Bonnet-Pressing Machine.

Bon'net-press'ing Ma-chine'. A machine by which bonnets while on the forming-block are presented to the flat or presser. In the example, the bonnet is placed crown upward upon the former *W*, which has a rocking adjustment by the ratchet *S* upon a frame *C*, whose pedestal is planted on the slide *B*, which has a traversing motion to bring the former and the bonnet beneath the presser *N* on the end of the horizontal arm *M*. This has a pressure, by means of springs, on the stem, while the *former* is rotated beneath the pressing-iron by means of the hand-crank and bevel-gearing.

Bon'ney. (*Mining.*) An isolated bed of ore.

Bon'ten. (*Fabric.*) A narrow woolen stuff.

Boo'by-hatch. (*Nautical.*) The covering of the scuttle-way or small hatchway which leads to the forecastle or *fore-peak* of small sailing-vessels.

Boo'by-hut. (*Vehicle.*) A sleigh with a hooded cover.

Boo'by-hutch. (*Vehicle.*) A roughly built covered carriage, used in some parts of England.

Book. 1. A number of sheets of paper bound together on edge, known as the *binding-edge*.

Anciently, books consisted of a continuous roll formed by pasting or glueing sheets of parchment or papyrus together. They were usually furnished with cases into which they were placed for preservation when not in use. See PAPER.

Before the discovery of papyrus — which, however, was at a very distant period — inscriptions were made on boards, inner bark of trees, afterwards on skins. Books with a back and leaves of vellum were made by Attalus, King of Pergamus, about 198 B. C. See PARCHMENT.

The manuscript rolls in Herculaneum consist of papyrus, which is charred and matted together by the fire. The rolls are nine inches long, and vary in diameter; each forms a separate treatise. The first printed books were printed on one side only, and the pages pasted together at the backs.

Pliny says that the Parthians write upon cloths. Livy speaks of books of linen inscribed with the names of magistrates and the history of the Roman Commonwealth, and preserved in the temple of the Goddess Moneta.

Aristotle is said to have been the first to collect a library with a general assortment of books. (STRABO.) Pisistratus of Athens and Polycrates of Samos had libraries, supposed to have been principally poetical works.

The public library of Pisistratus was removed to Persia by Xerxes.

The library of Alexander was kept in two precincts of the city, the Brucheion and the Serapeum. It contained from 400,000 to 700,000 books. Authorities (Gellius, Josephus, and Seneca) differ. Ptolemies Soter, Philadelphus, and Euergetes were its patrons. Philadelphus added the famous library of Aristotle to the collection. It was much injured by fire in the siege of Julius Cæsar. Antony added to it the library of Pergamus, collected by Eumenes. It was afterward injured by Theodosius, and destroyed by the Arabs, A. D. 640.

The first public library of Rome was founded by Asinius Pollio, on Mt. Aventine. This was followed by the libraries of Augustus, Octavia, and Tiberius. The Ulpian library of Trajan was attached by Diocletian to his thermæ.

A furnished library was discovered in Herculaneum. Round the wall it had numbered cases containing the rolls.

It is recorded that Plato bought three works of Philolaus, the Pythagorean, for ten thousand denarii, nearly $ 1500. Aristotle bought a few books of Spencippus for three Attic talents, nearly $2800. Jerome, A. D. 420, states that he ruined himself by buying a copy of the works of Origen. Alfred the Great gave an estate for one on cosmography, A. D. 872.

The book of St. Cuthbert, the earliest ornamental book, is supposed to have been bound about A. D. 650. A Latin Psalter in oak boards was bound in the ninth century.

In more modern times, Machlin's Bible, ornamented by Tomkins, was valued at £525. A superb copy of the Bible was printed and collected by Mr. Parker, of Golden Square, London, in about 54 large folio volumes, with 7,000 illustrations in the text and mounted, and containing original drawings by Loutherbourg and others, was insured in a London office for £3000. It was raffled off at £5000; 100 subscribers at £50 each. Two wagon-loads of a book at $ 25,000.

A standard dictionary of the Chinese language, containing 40,000 characters, was made by Pa-out-she about 1100 B. C. (MORRISON.) The Onomastikon, a Greek dictionary of Julius Pollox, was written about 120 B. C.

Sze-ma-tseen, the Chinese Herodotus, wrote in the second century B. C. The dictionary Si-wun was compiled about 148 B. C.

The Spanish Saracens compiled dictionaries, lexicons, encyclopedias, and pharmacopœias. The Historical Dictionary of Sciences of Mohammed Ibu Abdallah, of Granada, is a notable instance. Avicenna also wrote a large number of works, among them an Encyclopedia of Human Knowledge, in twenty volumes.

A manuscript copy of the Evangelists, the book on which the English kings, from Henry I. to Edward VI., took their coronation oath, was bound in oak boards, nearly an inch thick, in 1100.

Velvet was the covering in the fourteenth century. Silk soon after. Vellum in the fifteenth. It was stamped and ornamented about 1510. Leather came in use about the latter date. Cloth binding superseded the common paper-covered mill-boards about 1831. Caoutchouc backs to account and other heavy books were introduced in 1841. The rolling machine of William Burr (England) was substituted for the beating-hammer about 1830. See BOOKBINDING.

2. (*Gilding.*) A package of gold-leaf, consisting of 25 leaves, each $3\frac{1}{8} \times 3$ inches square; they are inserted between leaves of soft paper rubbed with red chalk, to prevent adherence.

Book-back Round'er. 1. (*Bookbinding.*) A machine which acts as a substitute for the hammer in rounding the back of the book after cutting the edge and ends. It is usually performed upon the book before the cover is put on.

In one form of machine, the book is run between rollers, being pressed forward by a rounded strip which rests against the front edge and determines the form thereof.

In another form, the book is clamped and a roller passed over the back under great pressure.

Another form of machine is for molding the back-covers of books to a given curvature, by pressing between a heated cylinder of a given radius and a bed-plate whose curvature corresponds to the presser.

Book-bind'er. A contrivance of the nature of a temporary cover, for holding together a bunch of newspapers, pamphlets, or similar articles. There are many forms of the device.

Book-bind'er's Tools, etc. See under the following heads: —

Album.
All-along.
Arming-press.
Backing-board.

Back-tools.
Band.
Band-driver.
Bead.
Beveling-machine.
Binding.
Bleeding.
Blind-blocking.
Blind-tooling.
Blocking.
Blocking-press.
Board.
Book (gold-leaf).
Book-back rounder.
Bookbinder.
Book-clamp.
Book-folding machine.
Book-sewing machine.
Boss.
Case.
Case-work.
Corner.
Covering.
Creaser.
Cropped.
Cutting-press.
Dentelle.
Edge-bolt.
Edge-cutting.
Edging.
Embossing.
Fillet.
Finishing-press.
Flexible binding.
Folding.
Folding-machine.
Fore-edge.
Forel.
Forwarding.
Foundation-plate.
Full-bound.
Gather.
Gilding-tool.
Glaire.
Glueing-machine.
Glueing-press.
Gouge.
Grater.
Guards.
Half-binding.
Hand-letter.
Head.
Head-band.
In-boards.
Inside-tin.
Interleave.
Joint.
Kettle-stitch.
Knocking.
Lacing.
Law-binding.
Laying-on tool.
Lettering-box.
Lettering-tool.
Marble-edge.
Marbling.
Mill-board.
Mitered.
Overcasting.
Pallet.
Panel.
Pawl-press.
Plow.
Pocket-book.
Point.
Polishing-iron.
Polishing-tin.
Porte-monnaie.
Portfolio.
Press-keys.
Roll.
Rolling.
Rolling-press.
Rounding.
Run-up.
Scratcher-up.
Screw-press.
Sewing.
Sewing-table.
Shaving-tub.
Signature.
Slip.
Square.
Stabbing machine.
Stamp.
Steamboating.
Stitching.
Stove, Bookbinder's
Tip.
Tooling.
Tools.
Turning-up.
Whipping.

Book-bind'ing. The art of attaching together and covering the sheets composing a book.

The earliest known forms of bookbinding, if the term be held to include all modes of attaching sheets together, is perhaps the Egyptian, which consisted in pasting or glueing the sheets together and rolling them upon small cylinders. The sheets were unrolled from one cylinder, and, after reading, rolled upon the other. The copy of the Pentateuch, in the possession of the small band of Samaritans yet living at Nablous, the ancient Gerizim, is thus preserved. It is claimed by its possessors to have been written by a grandson of Aaron. The book of the law in all synagogues is thus mounted.

Another ancient mode, the precursor of the more modern system, is found in the mode of stringing leaves together by several cords passing through holes near one edge. This is practiced in India with pieces of leaves neatly cut to a size. See PAPER; PEN.

The present plan of fastening the leaves to a back and sides is believed to have been invented by Attalus, of Pergamus, or his son Eumenes, about 200 B. C. This king, or somebody for him, invented parchment, hence called *pergamena*, from Pergamus. It was devised as a substitute for papyrus, on which an embargo had been laid by Ptolemy of Egypt, who thus sought to embarrass the rival library in Asia Minor.

The oldest bound book known is the volume of St. Cuthbert, *circa* 650.

Ivory was used for book covers in the eighth century; oak in the ninth. The "Book of Evangelists," on which the English kings took their coronation oath, was bound in oak boards, A. D. 1100.

Hog-skin and leather were used in the fifteenth century.

Calf in 1550.

Silk and velvet as early as the fifteenth century.

The Countess of Wilton, in her "Art of Needlework," says the earliest specimen of needlework-binding remaining in the British Museum is Fichetus (Guil.) Rhetoricum, Libri tres (Impr. in Membranis), 4to, Paris ad Sorbonæ, 1471. It is covered with crimson satin, on which is wrought with the needle a coat of arms, a lion rampant in gold thread in a blue field, with a transverse badge in scarlet silk; the minor ornaments are all wrought in fine gold thread.

The next in date in the same collection is a description of the Holy Land, in French, written in Henry VII.'s time. It is bound in rich maroon velvet, with the royal arms, the garter, and motto embroidered in blue, the ground crimson, and the fleurs-de-lis, leopards, and letters of the motto in gold thread. A coronet of gold thread is inwrought with pearls; the roses at the corners are in red silk and gold. In the Bodleian Library is a volume of the Epistles of St. Paul (black letter), the binding of which is embroidered by Queen Elizabeth; around the borders are Latin sentences, etc. Archbishop Parker's "De Antiquitate Britannicæ Ecclesiæ" (1572), in the British Museum, is bound in green velvet, embroidered with animals and flowers, in green, crimson, lilac, and yellow silk, and gold thread.

A folio Bible which belonged to Charles I., date 1527, is now preserved in the church of Broomfield, Essex, England. It is bound in purple velvet, the arms of England embroidered in raised work on both sides.

A will of 1427 devises several psalters in velvet bindings.

Cloth binding superseded the paper known in England as "boards" in 1823.

India-rubber backs were introduced in 1841.

Tortoise-shell sides in 1856.

Three fine specimens of old bookbinding are in the collection of James S. Grinnell, of Washington, D. C., and deserve notice as being representative of different styles.

1. A manuscript breviary of the fourteenth century, elaborately illuminated on parchment, has a brown calfskin cover over sideboards of beech, the bands being of calfskin passed through holes in the boards and wedged. The cover is elaborately blind-tooled, that is, not gilded, but worked by pressure and heat. The designs are in square panels of geometric figures.

The book is bound in folded signatures of five double sheets, making twenty pages to a signature, and the first letter on each of these parcels is written at the bottom of the previous parcel for the direction of the binder.

The book had brass clasps, and contains the "divine office" for the year. It is in remarkable preservation.

2. "Catalogus factorum et gestorum eorum et

diversis voluminibus collectus," edited by "the most reverend father in Christ, Petro de Natalibus." Printed in 1514.

Bound in white vellum, elaborately embossed with salient figures representing Faith, Hope, and Charity, kit-cat length in panels of the cover, surrounded by scrolls and leafage. The binding has the date of 1595, and the vellum was evidently embossed by being stamped while wet with dies engraved in *intaglio*. The panel borders were made by hand-tool fillets, not rolls. The figures are repeated in a manner which shows that the impressions are repetitions of the same stamp. The vellum was probably laid upon a material which would yield somewhat to pressure and then retain its form. The vellum was then dried in position.

3. A copy of John Minsheu's folio dictionary "Ductor in Linguas," published in 1617, and dedicated to James I. It was formerly in the library of Charles I., is bound in buff leather, and has the arms and crown on both sides of the cover.

The binding of books varies, and the following names occur: —

Full-bound; back and sides leather.

Half-bound; back leather, sides paper or cloth.

Cloth; back and sides covered with a colored fabric, usually embossed.

Muslin; same as above.

Boards; an English term. The covers were of mill-board. They were afterwards covered with paper.

Other modes are known by the kind of leather with which they or their backs are *full* or *half* bound; as, Russia, morocco, roan, calf, sheep, vellum, etc.

In one form of caoutchouc binding, the sheets are folded in double leaves, clamped, treated on the back with several coats of caoutchouc in solution.

The processes of bookbinding are about as follows:

Folding the sheets.

Gathering the consecutive signatures.

Rolling the packs of folded sheets.

Sewing, after saw-cutting the backs for the cords.

Rounding the backs and glueing them.

Edge-cutting.

Binding; securing the book to the *sides.*

Covering the sides and back with leather, muslin, or paper, as the case may be.

Tooling and *lettering.*

Edge-gilding.

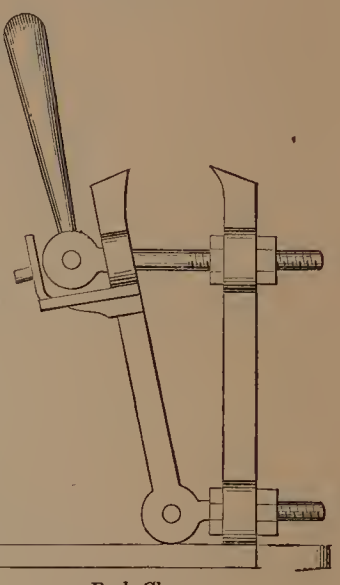
The British Museum Catalogue is a library of folios in itself. Every volume is stoutly bound in solid blue calf, with its lower edges faced with zinc, to save wear and tear from the violent shoving in of the volumes to their places.

The museum at Cassel, in Germany, has a collection illustrating European and other trees. It is in the form of a library, in which the back of each volume is furnished by the bark of some particular tree, the sides are made of perfect wood, the top of young wood, and the bottom of old. When opened, the book is found to be a box, containing either wax models or actual specimens of the flower, fruits, and leaves of the tree.

At a sale of rare books and manuscripts in Paris recently, there was disposed of a fourteenth century, illuminated, Gothic edition of the Bible, with gold clasps, set with turquoises and bound in human skin. A copy of the "Imitation of Christ," now in the Carmelite library at Paris, is similarly covered. The human skin is said to preserve its brilliant whiteness forever, while all other parchments will turn yellow. It possesses, besides, the advantage of being easily embossed, the Bible in question being beautifully ornamented with *fleurs de lys*, scepters, etc. On the other hand, it absorbs ink so freely that it is impossible to write upon it. The character of the skin is determined by the microscope. The human skin and its hair are readily distinguished from those of other animals.

Book-clamp. (*Bookbinding.*) *a.* A vise for holding a book while being worked. Adjustment is made by the nuts for the thickness of the book, and the pressure is given by the lever and eccentric.

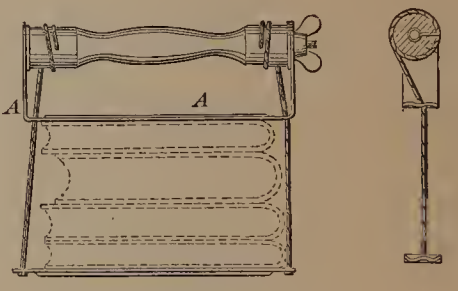
Fig. 791.



Book-Clamp.

b. A holder for school-books while carrying them. The cords pass through the upper bar *A* and down to the lower bar; they are tightened by the rotation of the handle.

Fig. 792.



School-Book Clamp.

Book-edge Lock. A lock whereby the closed sides of the book-cover are locked shut.

Book-fold'ing Ma-chine'. A machine for folding sheets for gathering, sewing, and binding.

Chambers's book-folding machines are made of various sizes, adapted to fold sheets to various dimensions from folio downward.

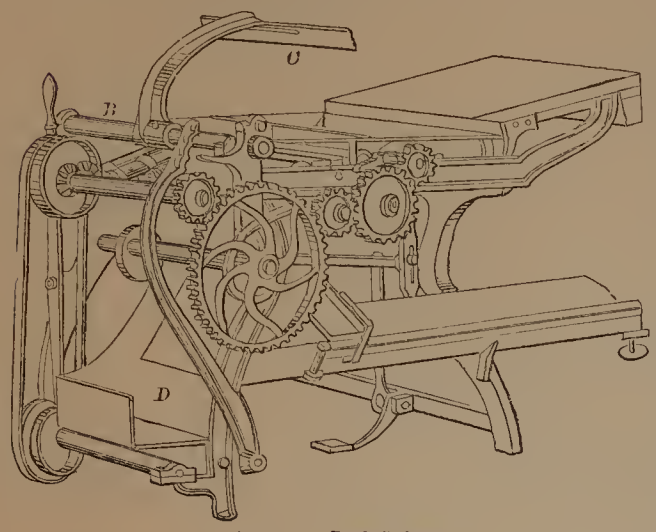
They are also adapted for folding two separate sheets together, pasting the separate pages at the back; or for cutting sheets into a number of pieces and folding them separately. Insets also may be cut off and set in as by hand.

Fig. 793 will give an idea of the folding process on a simple machine.

The operator transfers a sheet to the table *A*, which has a transverse slit across its middle. The revolution of the pulleys operates a rock-shaft *B*, carrying a curved arm with a folder *C* at its extremity, which presses the sheet down through the slit in the table, where it passes between rollers, which double it and deliver it into a receptacle *D*, at the end of the machine.

To fold an octavo, the once folded sheet is again presented to a folding edge, when it is carried to a second set of rollers, which squeeze it flat, and it is thence led to a trough, where the folded sheets are collected.

Fig. 793.



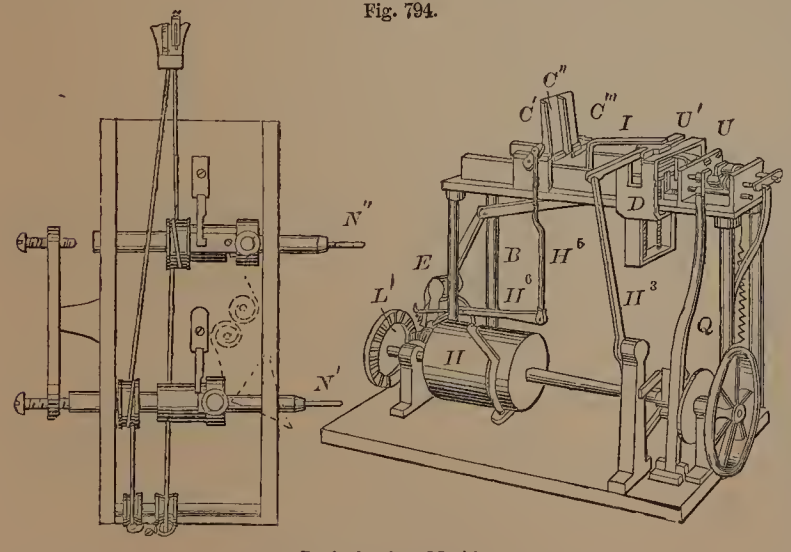
Chambers's Book-Folder.

Book-hold'er. A reading-desk top, or equivalent device, for holding an open book in reading position.

Book'ing. (*Agriculture.*) The arrangement of tobacco-leaves in symmetrical piles, the stems in one direction, *leaf* upon *leaf*, forming a *book*.

Book-sew'ing Ma-chine'. The feeder is composed of two plates *C' C''*, inclined each toward the other, and almost touching at their outer ends. When the feeder is in the position shown in the figure, a folded "signature" is placed over it, the feeder is brought to a horizontal position, and then a horizontal plate moves forward between the plates of the feeder, and carries the signature to the points of the hooked needles *N' N''*, which are then driven through the saw-kerfs in the back of the signature, and in this position a thread-carrier lays its thread in the hooks of the needles, and when the needles are carried back, they draw a loop of such thread through the back of the signature. When the needles pass into another signature, they draw the thread then laid within their hooks through the loops last formed and yet on their shanks, and so enchain the thread along the backs of and secure the signatures together. The feeder vibrates alternately from a vertical to a horizontal position; in the former receiving the signature which straddles it, and in the latter forming guides for the horizontal plate which pushes the signature of the feeder up to the place where it is sewn.

Fig. 794.



Book-Sewing Machine.

Book-mus'lin. (*Fabric.*) A fine, transparent goods, like a Swiss muslin. It comes folded in *book* form. See BUKE-MUSLIN.

Book-per-fect'ing Press. (*Printing.*) One which prints both sides of a sheet without intermediate manipulation. Some act upon the respective sides in immediate succession, others have automatic feed between impressions. Such are the *Ford*, *Bullock*, *Walter*, and other printing-presses of the highest character and efficiency.

Bool-work. See BUHL-WORK. See also REISNER-WORK.

Boom. 1. (*Nautical.*) *a.* A spar for extending the foot of a *fore-and-aft* sail.

The boom on which a fore-and-aft sail is stretched is commonly provided with jaws which partially encircle the mast, and are held to it by a half-grommet strung with balls of hard wood to avoid friction.

b. A spar rigged out from a yard to extend the foot of a *studding-sail*. The *fore* and *main lower* yards, and the *fore* and *main topsail* yards have *studding-sail booms*. Each is secured by *boom-irons* on its yard, and is named from the studding-sail whose foot it stretches.

The heads of the studding-sails are bent to studding-sail yards which are slung from the studding-sail booms and the fore and main top-gallant yard-arms. The stays of these booms are called *guys*.

The *ring-tail boom* is rigged out like a studding-sail boom at the end of the *spanker*-boom.

c. The *booms;* the space on the spar-deck between the fore and main masts, where the boats and spare spars are stowed.

2. (*Marine Fortification.*) A chain or line of connected spars stretched across a river or channel to obstruct navigation, or detain a vessel under the fire of a fort.

3. (*Lumbering.*) A spar or line of floating timbers stretched across a river, or inclosing an area of water, to keep saw-logs from floating down the stream.

Boom'e-rang. A missile formed of a bent stick with a rounded and a flat side, and used by the Australian natives.

Among the various throwing-sticks of savage nations, this weapon of the Australians has caused most curiosity, from the apparently erratic character of its flight. It is a curved stick, round on one side and flat on the other, about 3 feet long, 2 inches wide, and ¾ inch thick. It is grasped at one end and thrown sickle-wise, either upward into the air, or downward so as to strike the ground at some distance from the thrower. In the first case it flies with a rotatory motion, as its shape would indicate, and after ascending to a great hight in the air, it suddenly returns in an elliptical orbit to a spot near its starting-point. On throwing it downward to the ground, it rebounds in a straight line, pursuing a ricochet motion until it strikes the object at which it is thrown.

The most singular curve described by it is when it is projected upward at an angle about 45°, when its flight is always backward, and the native who throws it stands with his back to the object he intends to hit.

The ancient Egyptians used curved throwing-sticks; but their shape was not like the one above described, nor their flight anything very peculiar.

The Esquimaux and some Brazilian tribes use throwing-sticks. The Purupurus have the *palheta*, a missile of a similar kind.

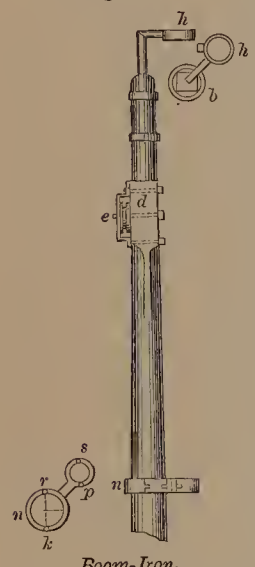
The *trombash* is a throwing-stick used by some of the interior tribes of Africa.

Another form of missile is the *bolas* of the Patagonians. See BOLAS.

The boomerang of the Moqui Indians, of Sonora, is a flat pointed stick, with a small ornament like an acorn at the handle end.

Boom-i'ron. (*Nautical.*) A flat iron ring on the yard, through which the studding-sail boom travels when being rigged out or in.

Fig. 795.



Boom-Iron.

One boom-iron, called the *yard-arm iron* (*b h*), is fixed at the end of the yard, and another iron, called the *quarter-iron* (*n*), is placed at $\frac{3}{16}$ of the length of the yard from the outer end.

The quarter-iron has a clasp *r k n*, which embraces the yard, and a clasp *s p*, which holds the heel of the studding-sail boom. *d* is the stop of the yard, and to it is secured the *check-block* *e* for the *sheets*.

Boom-jig'ger. (*Nautical.*) A tackle for rigging out or running in a topmast studding-sail boom.

Boom'kin. (*Nautical.*) A projecting spar at the bow of a ship, for hauling out the weather-tack in sailing near the wind. *Bumkin.*

A *fore-boom*, or bentick-boom, is sometimes used for spreading the foot of the fore-sail.

Booms. (*Nautical.*) A space amidships on the spar-deck, between the fore and main masts, where the launch or other large boat and spars are stowed.

Boon. The internal woody portion or pith of flax, which is disorganized by *retting*, the binding mucilage being softened by fermentation. The *boon* is partially removed in *grassing*, and together with the *shivcs* is completely eliminated from the *harc* or fiber in the subsequent operations of *braking* and *scutching*.

Boot. 1. (*Leather.*) A covering for the foot and lower part of the leg, made ordinarily of leather.

The various parts are designated in the illustration.

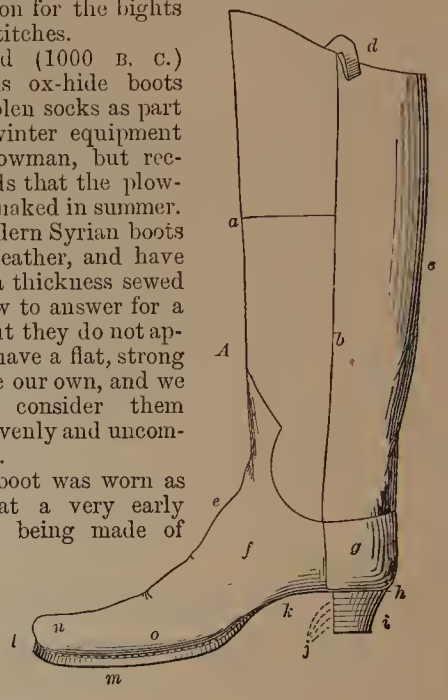
In the elevation *A* (Fig. 796), —

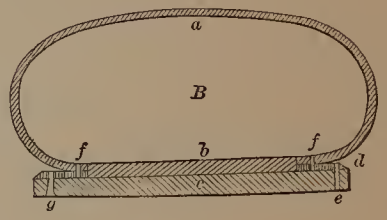
a is the *front*.
b the *side-seam*.
c the *back*.
d the *strap*.
e the *instep*.
f the *vamp* or *front*.
g the *quarter* or *counter*.
h the *rand*.
i the heel; the front is the *breast*, the bottom the *face*.
j the *lifts* of the heel.
k the *shank*.
l the *welt*.
m the *sole*.
n the *toe*.
o the *ball* of the sole.

In *B*, (same figure), —

a is the *upper*.
b the *insole*.
c the *outsole*.
d the *welt*.
e the *stitching* of the *sole* to the *welt*.
f the stitching of the *upper* to the *welt*.
g the *channeling*, or the depression for the bights of the stitches.

Fig. 796.





Boot.

Hesiod (1000 B. C.) mentions ox-hide boots and woolen socks as part of the winter equipment of a plowman, but recommends that the plowman go naked in summer. The modern Syrian boots are of leather, and have an extra thickness sewed on below to answer for a sole; but they do not appear to have a flat, strong sole like our own, and we should consider them very slovenly and uncomfortable.

The boot was worn as armor at a very early period; being made of leather with plates or greaves of metal to guard the front.

Moses says of Asher, "Thy shoes shall be iron and brass." 1451 B. C.

Homer, in his "Iliad," speaks of the brazen-booted Greeks.

In the Abbott Collection, New York, may be seen ancient Egyptian boots and shoes, of purple and red leather, and of white kid. Sandals were the common wear, and were made of leather, raw-hide, date-leaves, and papyrus. In the same collection is the mummied foot of a lady with the white kid gaiter boot yet remaining upon it. The foot is small and finely arched, resembling the true Arabian type. The boot is so fragile that it will not bear handling. The upper appears to be sewed to a sole, but does not show any heel. It is from Sakkarah.

The Median and Roman boots were laced up in front. See *Cothurnus*, in Smith's "Dictionary of Greek and Roman Antiquities."

The boot was called *ocrea* by the Romans. The *calceus* was a *shoe*, and the *solea* a *sandal*. The shoes of the Roman senators came up to the middle of the leg, and were generally *black*. On ceremonial occasions the Roman magistrates wore *red* shoes. Red and purple were regal, and red is yet a cardinal color.

The Etruscan augurs wore jack-boots.

The Lamas of Tartary wear red boots and yellow cloaks. They leave their boots in the vestibules of the temples. So do the Turks. The latter brought the practice from Central Asia.

"There bought a pair of boots; cost me 30 *s.*" — PEPYS, 1662.

The boot and shoe making business, more particularly since the introduction of pegs, which are said to have been invented by Joseph Walker, of Hopkinton, Mass., about the year 1818, has become a very extensive and important branch of manufacture, machinery being employed in nearly all the operations connected with the business. The first application of machinery in shoemaking is due to the celebrated Brunel, who devised a series of machines, which were operated by invalid soldiers belonging to Chelsea Hospital. The shoe passed through a number of hands before being finished; the operation which each man had to perform was so simple that it is said that the manipulation could be learned in half an hour. The sole was secured to the upper by nails. These machines, being employed solely for the manufacture of army shoes, appear to have fallen into disuse at the close of the war, and were never introduced into private establishments, the style of work probably not being suited to the demands of the public.

A long-legged boot made in Worcester, Mass., for the Pennsylvania coal-mines, is the most durable piece of furniture ever constructed of leather and iron. The soles are about three quarters of an inch thick, projecting like the guards of a Mississippi steamer. The heel also projects nearly a quarter of an inch, forming quite a shell near the counter, and flared at the bottom. Nails with a flat top, a size smaller than a three-cent piece, are driven as closely as they can be set all over the sole, shank, and heel, forming as it were a solid iron bottom. The boots weigh 6½ pounds, the nails contributing 1½ pounds to the weight. Long nails of Swedish iron are driven through the heel and shank, clinching on the inner sole; three to the heel and six to the shank. The sides are closed by hand with a six-stranded thread that will hold 100 pounds weight.

2. (*Carriage.*) The receptacle for baggage, etc., at either end of a coach.

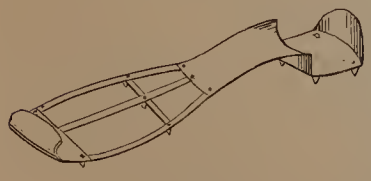
3. (*Menage.*) Protection for the feet of horses, enveloping the foot and a part of the leg. A convenient substitute for swaddling or bandaging. Patented in England by Rotch, 1810.

They are used on the feet of horses while standing in a stable, to keep the feet moist and prevent cracking or contraction of the hoofs. They may be lined with sponge, which is kept damp. The boot has an upper and sole, and is shaped to the foot nearly. The upper part has a draw-string.

They are also used for various affections of the legs and feet, such as varicose veins, splint, speedy-cut, strain. In such cases they are made to fit more closely.

Boot-calk. A spur for the boot-sole to prevent the wearer from slipping on ice.

Fig. 797.



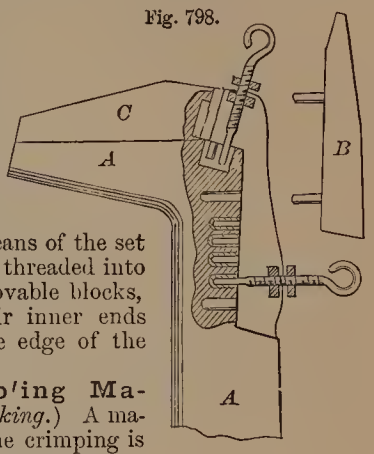
Boot-Calk.

Boot-chan'neling Ma-chine'. One for making the slit in a sole to sink the sewing-thread below the surface. It consists of a jack on which the boot is held, an inclined knife gaged to depth, and a guide which causes the knife to make its incision at an equal distance from the sole-edge all round.

Boot-clamp. A device for holding a boot while being sewed. It consists of a pair of jaws, between whose edge the leather is gripped, and which are locked together by a cam, or by a cord which leads to a treadle.

Boot-crimp. (*Boot-making.*) A tool or a machine for giving the shape to the pieces of leather designed for boot uppers. Formerly the leather made a series of folds or crimps over the instep, and hence may have originated the name. The leather for uppers is now crimped by softening, straining over a former, and rubbing down the parts where the leather is thickened by the operation; that is, the parts which would be *crimped* or rugged, were the material not compacted at that point.

Fig. 798.



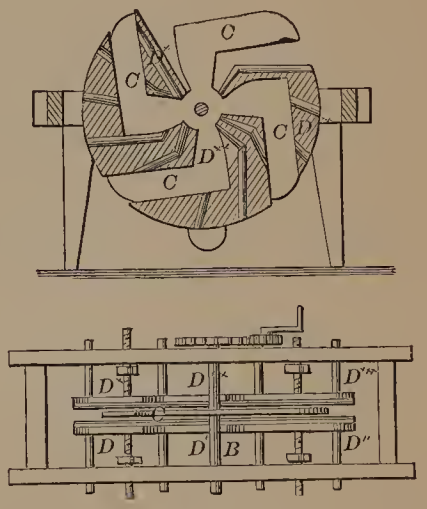
Boot-Crimp.

In the illustration, the edges of the leather are tacked over the pieces *C B*, which are then extended outwardly from the block *A* by means of the set screws, which are threaded into sockets in the movable blocks, and bear by their inner ends in pockets on the edge of the block *A*.

Boot-crimp'ing Machine'. (*Boot-making.*) A machine in which the crimping is performed in succession upon a number of leather pieces cut to a pattern.

The boot-trees *C* are attached to a central shaft, which carries them around in contact with the adjustable ribs *D D*, which are so bent as to crimp the leather upon the trees.

Fig. 799.

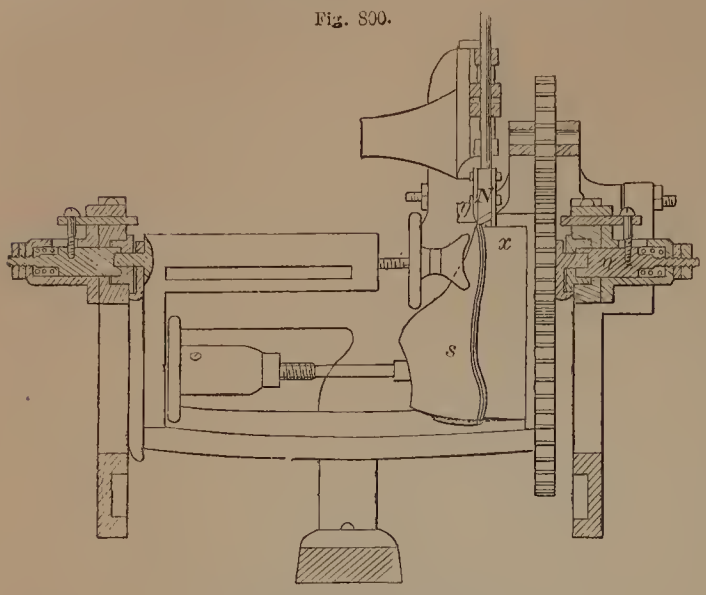


Boot-Crimping Machine.

Boot-edge Trim'mer. A machine which acts in connection with a guide to pare smoothly the edges of boot-soles. It is a machine-substitute for the edge-plane.

In the machine (Fig. 800), vertical, endwise, and rotary movements are imparted to the jack in which the shoe *s* is clamped. The gage *y* runs between the sole and upper leather of the shoe, and prevents the paring-knife from cutting into the upper leather. The cutter-head *N* rests upon the pe-

Fig. 800.



Boot-Edge Trimming Machine.

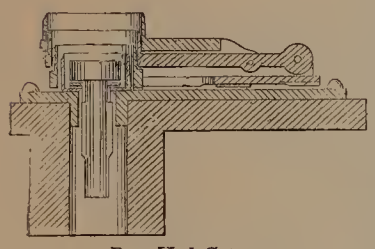
riphery of the pattern *x*, which governs the depth of cut.

Boot'ee. (*Fabric.*) A white, spotted Daccamuslin.

Boot-groov'ing Ma-chine'. One for making the groove in a shoe-sole to sink the sewing-threads below the surface. A *channeling-machine.*

Boot-heel Cut'ter. A machine for cutting the lifts for making boot-heels. In the example the cutters are various in size, and are hinged to the frame, so that they can be let down over each other. The heel-lifts are cut to graduated size, and merely require beveling after attachment. The leather is placed on the cutters, and forced down by blows of a wooden mallet.

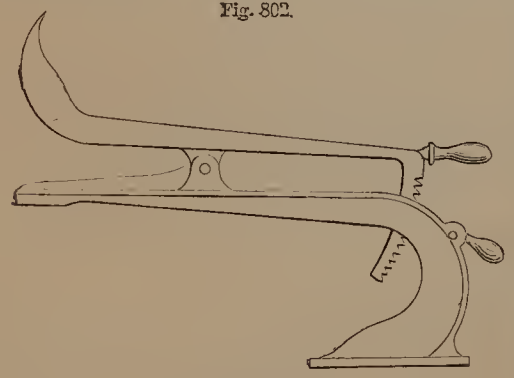
Fig. 801.



Boot-Heel Cutter.

Boot-hold'er. A jack for holding a boot either in the process of manufacture or for cleaning. The base-piece is attached to a bench, and has a stationary prong. The movable prong, containing the foot-piece, is attached to the other, and is held at its adjustment by a curved rack and pawl.

Fig. 802.



Boot-Holder.

Boot-hook. A device for drawing on boots and shoes, consisting essentially of a stout wire bent into a hooked form and provided with a handle.

Boot-jack. A board with a crotch to retain the heel of a boot while it is being pulled off.

Boot-jacks are made jointed, so as to fold into compact form. Recesses are made in them to hold a small brush and a minute box of blacking. Cases are made to contain all three, being nattily arranged to suit the fastidious.

A boot-rack is merely a frame to hold boots, and would not be here cited but that several patents have been granted for special contrivances in that line.

Boot-mak'ing Ma-chine'. Screws have been employed in France since 1844 for securing soles to shoes.

Machines for making boots are adapted for specific parts of the operation; such as *heel-machines*, which include *cutters*, *randing*, *heel-cutting*, *heel-trimming*, and *heel-burnishing* machines.

Upper-machines; which include *crimping*, *turning*, *seam-rolling*, and *trimming* machines.

Sole-machines; which include *cutting*, *channeling*, *burnishing*, and *pegging* machines.

Lasting-machines; for drawing the upper portion of the boot firmly on to the last.

Pegging-machines; pegging-jacks for holding boots while being pegged.

Crimping-machines; for stretching and pressing into shape leather for uppers.

Besides these there are numerous hand-tools, such as *burnishers*, *edge-planes*, and *shaves*, *pegging-awls*, etc. See list under LEATHER.

In one arrangement of screw-wire boot-making machinery is the following series: —

The leather is cut into shape by means of tools resembling punches. The thicknesses which are to form the soles are united with glue, and compressed previously to being cut. They receive then the necessary concavity by powerful hydraulic pressure, and their surfaces are smoothed and hardened in still another machine. Sewing-machines form all the necessary seams, binding, and, if necessary, ornamental stitching of the upper leathers; and then the separate parts are brought together in the machine which is to complete the shoe by uniting the upper leather and the sole.

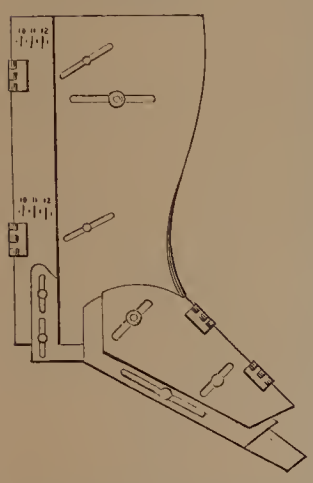
First there is placed upon the form or last in this machine the inner sole. The upper leather is then stretched over this by means of small nippers attached to the machine, which are capable of stretching it with considerable force. It is secured in place by a row of small nails. The outer sole is then carefully applied over the whole. As this has been entirely finished and polished on the edges in the previous process of preparation, it is important that it be truly adjusted, since it cannot be afterwards trimmed. The machine then applies to the two soles, with the upper leather included between them, a force of pressure of not less than 700 pounds, increased, if desired, to one ton. Screws are then inserted all round the margin of the sole, an operation completed in less than three minutes for a single shoe, or in five minutes for a pair. The salient extremities of the screws are cut by a chisel, and the burr left by the chisel is ground away on an emery-wheel. The last on which the shoe is constructed, being made of iron, prevents the interior extremities from passing the surface of the inner sole.

The machines not only apply, but make the screw. The material is brass, which is drawn off from a bobbin in the machine as it is required. The extremity

passes horizontally through a guide, and, in order to cut the thread of the screw, the whole bobbin revolves. In hand-machines a crank serves to give the revolution ; but the driving power may be taken from a motor. When the resistance shows that the screw has struck the iron last, a cutter is brought into action by the foot of the operator pressing upon a pedal, and the wire is cut as near as possible to the leather.

Boot-pat'tern. A templet made up of plates which have an adjustment on one another, so as to be expanded or contracted to any given dimensions within the usual limits of boot sizes. Used in marking out shapes and sizes on leather ready for the cutter.

Fig. 803.

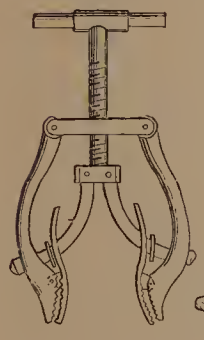


Boot-Pattern.

Boot-seam Rub'ber. A burnishing-tool for flattening down the seam where the thicknesses of leather are sewed together. This is usually a hand-tool, but sometimes is a machine in which a boot-leg, for instance, is held on a jack while the rubber, either a roller or a burnisher, is reciprocated upon the seam.

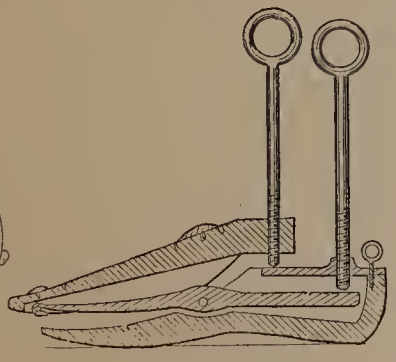
Boot-shank Ma-chine'. A tool for drawing the leather of the upper or boot-leg over the last into the hollow of the shank. In the example, the leather, being placed over the last, is inserted between the jaws which are pivoted to the plate. The screw connecting with the jaws by arms is then turned, and causes the jaws to be brought together, thus stretching the leather.

Fig. 804.



Boot-Shank Machine.

Fig 805.



Boot-Stretcher.

Boot-stretch'er. (*Leather.*) A device for stretching the uppers of boots and shoes. The common form is a two-part last, divided horizontally and having a wedge or a wedge and screw to expand them after insertion in the boot.

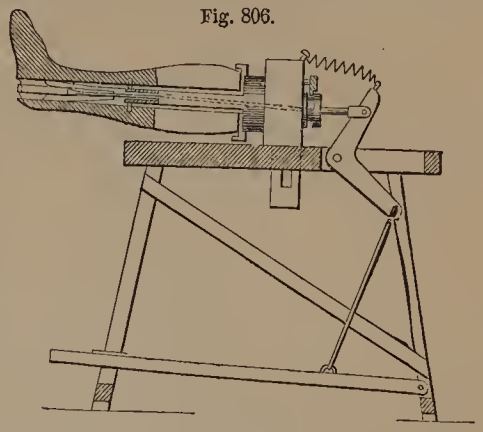
In the example the last is divided into an upper and under section which are connected by a lever. The fore end of the upper section is pivoted to the fore end of the lever, and the middle end of the lever is fulcrumed at the mid-length of the lower section. The screws operate to raise the rear end of the upper section immediately, and its fore end through the medium of the lever. The upper surface of the last has changeable knobs to stretch the leather in particular places.

There are many kinds for special uses.

Boot-top'ping. (*Nautical.*) The operation of scraping off grass, barnacles, etc., from a vessel's bottom, and coating it with a mixture of tallow, sulphur, and rosin.

Boot-tree. An instrument composed of two wooden blocks, constituting a front and a rear portion, which together form the shape of the leg and foot, and which are driven apart by a wedge introduced between them to stretch the boot. The foot-piece is sometimes detachable. In the illustration the tree is shown mounted on a trestle, the center wedge being driven by the motion of a treadle.

Fig. 806.



Boot-Tree.

Boot-ven'ti-la'tor. A device in a boot or shoe for allowing air to pass outwardly from the boot so as to air the foot. It usually consists of a perforated interior thickness, a space between this and the outer portion, and a discharge for the air, through some part of the said outer portion above the water-line.

Bo'quin. (*Fabric.*) A coarse Spanish baize.

Bord. (*Mining.*) A lateral passage where a shaft intersects a seam of coal.

Bor'der. 1. (*Milling.*) The *hoop*, *rim*, or *curb* around a bedstone or bedplate, to keep the meal from falling off except at the prescribed gap. Used in gunpowder mills and some forms of grain-grinding mills.

2. (*Printing.*) *a.* A type with an ornamental face, suitable for forming a part of a fancy border.

b. Ornamental work surrounding the text of a page.

3. (*Locksmithing.*) The rim of a lock.

4. (*Fabric.*) That part of cloth containing the selvage.

Bor'der-pile. (*Hydraulic Engineering.*) An exterior pile of a coffer-dam, etc.

Bor'der-plane. A joiner's edging-plane.

Bor'ders. (*Fabric.*) A class of narrow textile fabrics designed for edgings and bindings ; such as galloons and laces.

Bor'der-stone. The curbstone of a well or pavement.

Bore. 1. (*Metal-working.*) A tool *bored* to fit the shank of a forged nail, and adapted to hold it while the head is brought to shape by the hammer. The depression in the face of the *bore* is adapted to the shape required of the chamfered under part of the head.

2. The cavity of a steam-engine cylinder, pump-barrel, pipe, cannon, barrel of a fire-arm, etc. In mechanics it is expressed in inches of diameter ; in cannon in the weight in pounds of solid round shot adapted thereto, as 8 dr., 12 dr., or in inches of diameter, as, 8-inch gun, 12-inch gun ; in small-arms, in hundredths of an inch decimally, thus, .44, .55, in this case it is termed *caliber ;* in sporting rifles by the number of balls to the pound ; in smooth-bore fowling-pieces by a trade number, as No. 9, 10, 11, etc.

2. The caliber of a wind-instrument; as, the *bore* of a flute.

3. The capacity of a boring-tool; as, the *bore* of an auger.

Bor'el. (*Fabric.*) *a.* Formerly, a coarse woolen cloth.

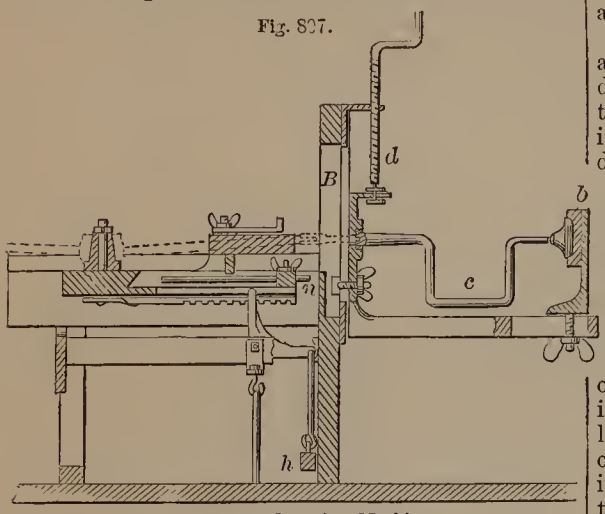
b. A light stuff with a silken warp and woolen woof.

Bor'er. (*Coopering.*) A semi-conical tool used to enlarge bung-holes and give them a flare.

Bo-ril'la. (*Metallurgy.*) A rich copper ore in dust.

Bor'ing and Ten'on-ing Ma-chine'. (*Wheelwrighting.*) One adapted to bore the holes in the fellies and to cut the tenons on the ends of the spokes. In the example, the wheel is mounted on sliding-bed

Fig. 807.



Boring and Tenoning Machine.

D, and pressure on the treadle *h* draws the spoke to the hollow auger, whose stock is turned by hand till arrested by the stop *n*. For boring fellies a detachable bed is fitted on the sliding carriage. A screw-clamp in the bed holds the felly, which is moved up to the auger, turned by hand as in the former case, and arrested by a gage-stop. The brace *c* is mounted between the back-plate *b* and a socket in the standard *B*.

Bor'ing-bar. (*Metal-working.*) A bar supported axially in the bore of a piece of ordnance or cylinder, and carrying the cutting-tool, which has a traversing motion, and turns off the inside as the gun or cylinder rotates.

Also, a cutter-stock used in other boring-machines, such as those for boring the brasses of pillow-blocks.

Bor'ing-bench. (*Wood-working.*) A bench fitted for the use of boring machinery or appliances. BENCH-DRILL.

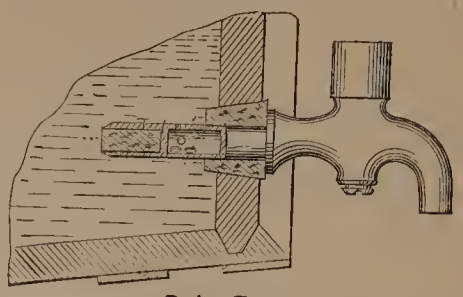
Bor'ing-bit. A tool adapted to be used in a brace. It has various forms, enumerated under the head of BIT (which see).

Bor'ing-block. (*Metal-working.*) A slotted block on which work to be bored is placed.

Bor'ing-col'lar. A back-plate provided with a number of tapering holes, either of which may be brought in line with a piece to be bored and which is chucked to the lathe-mandrel. The end of the piece is exposed at the hole to a boring-tool which is held against it.

Bor'ing-faucet. One which has a bit on its end by which it may cut its own way through the head of a cask. In casks whose holes are already plugged with cork the inner edge of the stem of the tap is made hollow to receive the cylinder of cork, and with an annular cutting-edge. A stop is placed in

Fig. 808

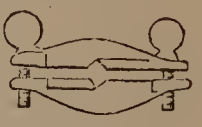


Boring-Faucet.

the stem to prevent the cork cylinder from reaching and closing the holes in the stem.

Bor'ing-gage. A clamp to be attached to an auger or a bit-shank at a given distance from the point, to limit the penetration of the tool when it has reached the determinate depth.

Fig. 809.



Boring-Gage.

Bor'ing-lathe. A lathe used for boring wheels or short cylinders. The wheel or cylinder is fixed on a large chuck screwed to the mandrel of a lathe.

Bor'ing-ma-chine'. The term may be held to have a somewhat general application to all machines by which holes are made by the revolution of the tool or of the object around the tool, but not including the simple tool itself. Thus an auger, gimlet, awl, or any *bit* adapted for boring, independently of the machinery for driving it, would not be a boring-machine. A *brace* is on the dividing line, if such there be, but is not included under the term *boring-machines*.

Borers for metal, however, are usually classed as drills, and in the present classification the bits and tools for metal will be classed as *drills*, the means for driving them as *drilling-machines*, excepting the largest class, which *bore out* large cylinders, ordnance, etc. We get back again to the term *boring* at this point, despite our attempts to preserve the unity of classification. These machines have usually a *boring-bar* or *cutter-bar*, which occupies the axis of the object which is being bored, and as three parts are involved and two motions required, several possible transpositions might be anticipated and various trinary combinations actually exist.

1. The parallel shaft of the boring-bar slides accurately in a groove exactly parallel with the bore; the cutting-blade is a small piece of steel affixed to the end of the half-round block, and the cut is advanced by a rack and pinion movement, actuated either by the descent of a constant weight or by an automatic motion derived from the prime mover. This is used in boring ordnance.

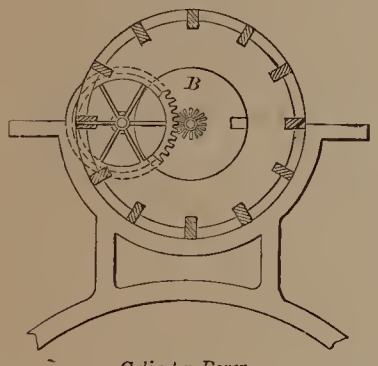
2. The cutter-bar revolves without longitudinal motion on fixed centers, like a spindle in a lathe; the work is traversed longitudinally past the rotating cutter, being supported on a slide-rest. This mode requires that the cutter should measure between the supports twice the length of the work to be bored, and the cutter to be at the midlength of the bar.

3. The cutter-bar revolves and also slides with an endwise motion, the work being at rest; the bearings of the bar are frequently attached to some temporary support in the work to be bored, as, for instance, a cast-iron cross at each end of the cylinder. The crosses are bored exactly to fit the boring-bar, one of them carries the driving-gear, and the bar is thrust endwise by means of a screw moved by a ratchet-wheel.

In another arrangement the boring-bar is mounted in head-stocks, much the same as a traversing mandrel; the work is fixed to the bearers carrying the head-stocks, and the cutter is advanced by a screw. The screw is then moved by a ratchet-wheel, or by the hand of the workman, one tooth in each revolution; or else by a system of differential wheels, in which the external screw has a wheel, say, of 50 teeth, the internal screw a wheel of 51 teeth, and a pair of equal pinions drives these two screws continually, so that an advance of $\frac{1}{50}$ of a turn of their screw, or their difference, is equally divided over one revolution of the cutter-bar, as in the feed-motion of the hand-drilling machine with the differential feed. This method only requires the fixed bearings of the cutter-bar to be as much longer than the work as the length of the cutter-block, but the bar itself must be more than twice the length of the work, and slides through the supports.

4. The boring-bar revolves upon fixed bearings without traversing, and it is only needful that the boring-bar should exceed the length of the work by the thickness of the cutter-block, of which it has commonly several of different diameters. The cutter-block, now sometimes 10 feet in diameter, traverses as a slide on a spline down a huge boring-bar *B*, whose diameter is about 30 inches. The motion of the cutter-block is caused by a side-screw, upon the end of which is a large wheel that engages in a small pinion *fixed* to the stationary center or pedestal of the machine. With every revolution of the cutter-bar, the great wheel is carried around the fixed pinion, and, supposing these to be as 10 to 1, the great wheel is moved $\frac{1}{10}$ of a turn, and imparts an equivalent motion to the feed-screw that moves the cutter-block.

Fig. 810



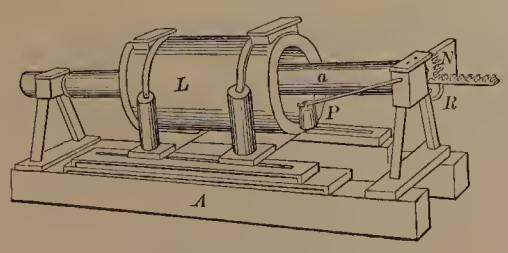
Cylinder Borer.

This machine was invented by George Wright when in the employment of Boulton and Watt, Birmingham, England.

A machine substantially the same, but with a different feed arrangement, is shown in the accompanying illustration.

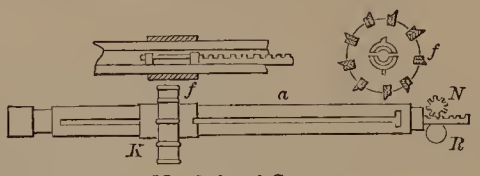
The boring-machine (Figs. 811 and 812) has a cutter-head revolving with and sliding on a mandrel *a*, which is in the axis of the cylinder. The cylinder *L* is secured to the bed *A* of the machine in exact conformity to the axial position of the mandrel *a*. The mandrel is a hollow iron tube with two opposite longitudinal slots, through which the action of the advancing apparatus is communicated to the cutter-head *f*, which is sleeved upon the mandrel *a*. The cutter-head consists of two parts: a sleeve *K*, which fits upon the mandrel, and a head *f*, which is secured upon the sleeve by wedges, and has cutters inserted into notches in its periphery. The sleeve *K* slips longitudinally on the mandrel *a*, but is restrained from revolving on it by two transverse bars, which act as a spline, and also connect the sleeve with a rack-bar inside, by which its longitudinal motion is effected. The rack-bar rests upon a roller *R*, and is moved by a pinion *N*, to which is connected a lever-arm having a weight *P* on its end. The cutters having been proved to revolve truly, the cutter-head is advanced, and is kept pressed against its work by the weight of the lever, which exerts a constant strain upon the rack. As soon as the lever has descended, it is again raised by hand, and this is the only attention necessary.

Fig. 811.



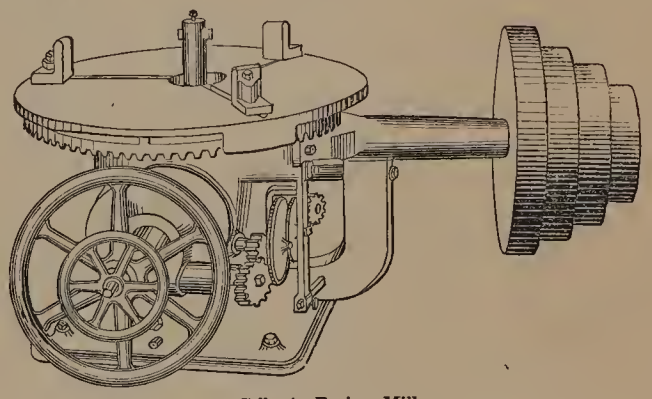
Cylinder Boring-Machine.

Fig. 812.



Mandrel and Cutter.

Fig. 813

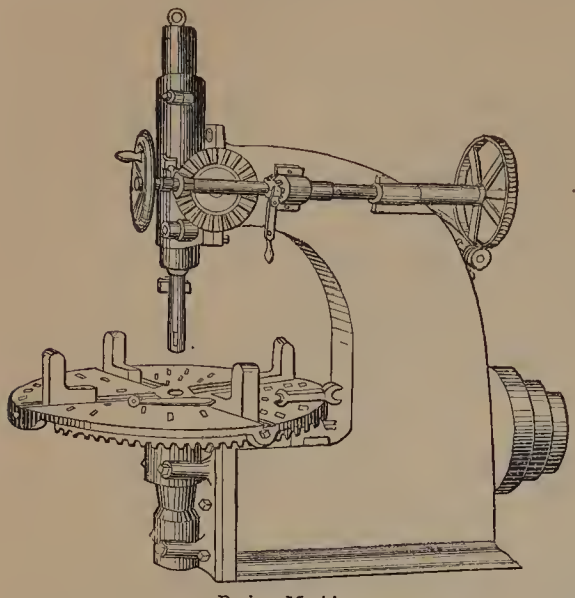


Sellers's Boring-Mill.

5. The work is dogged to a rotating-table, and the cutter is advanced as in Sellers's boring-mill (Fig. 812). This is a heavy boring-machine for car-wheels and general work, fitted with universal chuck for all sizes up to 36 inches diameter, and capable of boring driving-wheels 6 feet in diameter; the cross-head for holding the boring-bar is counterbalanced and arranged with power-feed and quick hand-traverse in either direction; the sliding surfaces are kept clear of chips which fall through the face-plate as in mills where the bar is supported above, as in Fig. 814.

A vertical boring-machine, expressly adapted for boring car-wheels, yet also available for many kinds of miscellaneous boring. It is so made as to be readily adjusted for taper or parallel holes, has rack and pinion feed with counterbalanced bar. For holding wheels or other work, a chuck is fitted to the bed, which retains the work in place while

Fig. 814.

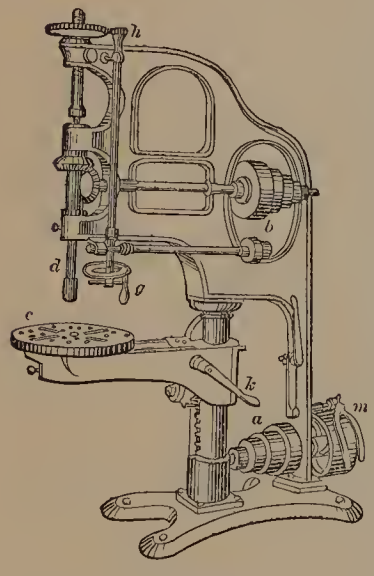


Boring-Machine.

being operated upon by means of jaws of the proper shape, and moving independently of each other. These jaws are made of wrought-iron case-hardened. The swing of the machine is four feet.

Fig. 815 shows a boring-machine of medium size, having a horizontal face-plate *c* on which the work is dogged. *a b* are the nests of pulleys by which graduated speed is given to the boring-shaft *d*. The latter is advanced to its work or retracted by means of the hand-wheel *g*, or the automatic feed-arrangement *h* may be thrown into gear. *k* is the handle acting upon a pinion and rack, to raise or lower the table *c*. *m* is the belt-shifter.

Fig. 815.



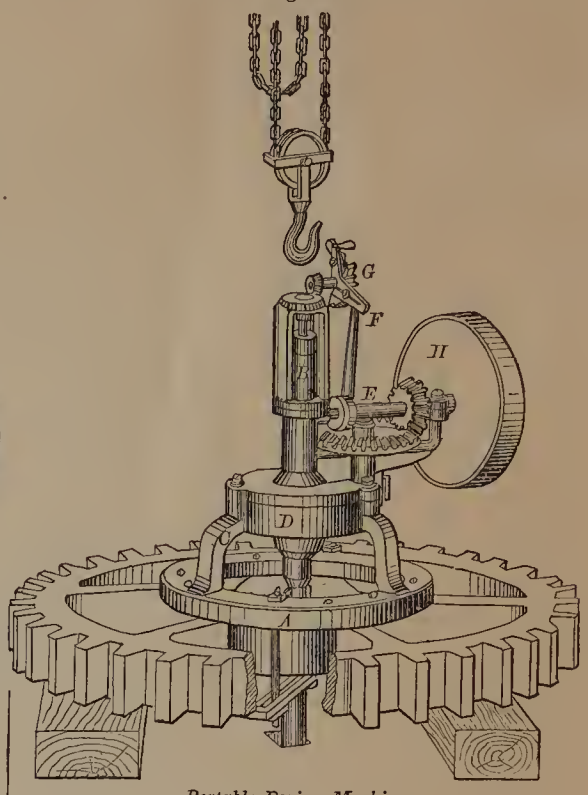
Boring-Machine.

Another form of boring-machine, by which the turret of a "Monitor" may be bored within and turned off without, is described under LATHE. Its bed is a face-plate on a vertical axis. The tools are held in a cross-slide, which is fitted to two uprights, resting on cheek-pieces bolted to the main casting or foundation-piece.

6. The borer is portable, and is dogged to the work.

The *portable boring-machine* (Fig. 816) is adapted to set vertically upon the work in cases where it is easier to bolt the machine to the work than to dog the work in the machine. The base-plate *A* of the drill is bolted to the face of the wheel in the example given, and is rotated by bevel-gearing from the axle of the band-wheel *H*. The box *D* holds the wheel on the drill-stock *B*, and the pinion which

Fig. 816



Portable Boring-Machine.

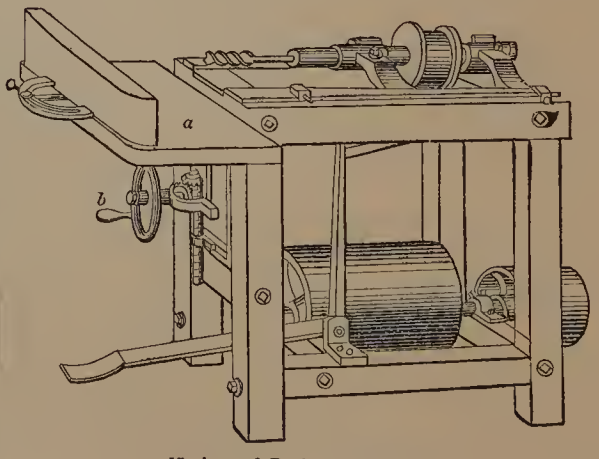
drives it, and is supported by legs *C* on the bed-plate. The feed is by means of an eccentric *E* and rod connected by an arm *F* to bevel-gearing which rotates the feed-screw, whose nut is swiveled in the top of the drill-stock. A click *G* engages the ratchet-wheel so as to hold the latter during the return motion of the arm *F*. The machine is slung by the tackle above when shifting its position.

7. (*Wood-working.*) A general difference in the style of the tools between those employed for wood and those for metal gives opportunity for distinguishing between the two classes of machines, although it must be admitted that the modes of propulsion in some machines of the respective classes are very similar, and that the boring *bits* for hard wood are much like the *drills* for metal.

The one are described as *augers* and *bits;* the other as *drills*.

Fig. 817 represents a horizontal boring-machine

Fig. 817.

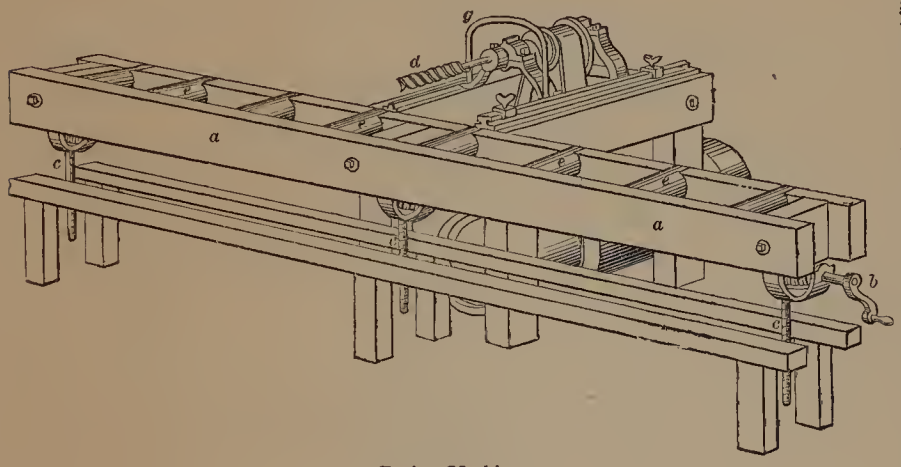


Horizontal Boring-Machine.

for carpenter's and machine shops, for pattern-makers, carriage, piano-forte, and all cabinet work, etc. The boring-shaft runs in stationary boxes; the table *a*, with stuff, slides up to the bit, and is raised and lowered by a screw and hand-wheel *b*, as desired. The boring and counter-shafts have cone-pulleys for a change of speed. These machines are arranged for augers with round or square shanks.

The machine Fig. 818 is very generally used for car work, and does a variety of boring without the trouble of setting out for the work. The carriage *a* is 12 feet long by 1 foot wide, is raised and lowered by a crank-shaft *b*, and screws *c c*, to bring the work to the right position with the bit *d*, and is held in place on the rear side of the frame. The bit is drawn up to the work by a bowed handle *g* on the front end of a boring shaft-slide. The timber laid upon the carriage is moved horizontally on iron rolls *e*, to finish the work. The counter-shaft has tight and loose pulleys.

Fig. 818.



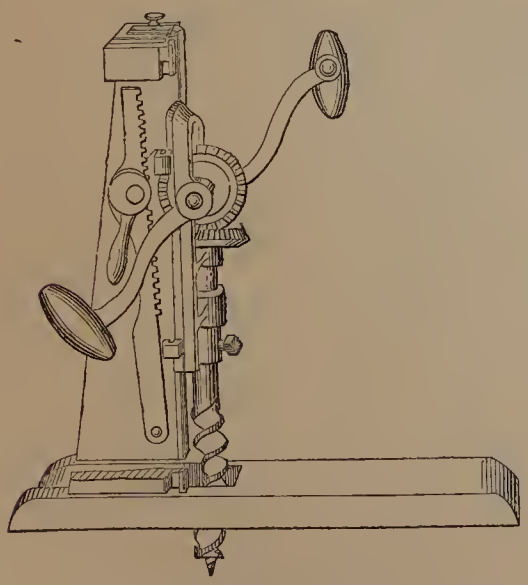
Boring-Machine.

8. The *carpenter's boring-machine* simplifies the business of making mortises by boring a hole perpendicularly or at any required angle. The auger is rotated by the double-crank shaft and the intervention of bevel-gearing. The auger feeds it into the wood, but pressure can be brought thereon if necessary. The auger is raised vertically from the hole by throwing the rack at the side in gear with a wheel on the crank-shaft, and rotating the latter. The rack is thrown in and out by an eccentric; an arrangement patented by Stanley and Johnson, September 12, 1865.

Boring-machines of various kinds are in use in bedstead, furniture, and other manufactories. In some cases the bits or augers are arranged in gangs in a gate or slide, which is slipped forward towards the work, making a whole row of holes of a given depth. This is the plan in making the holes in the round bedstead-rails for the reception of the pegs which hold the ropes.

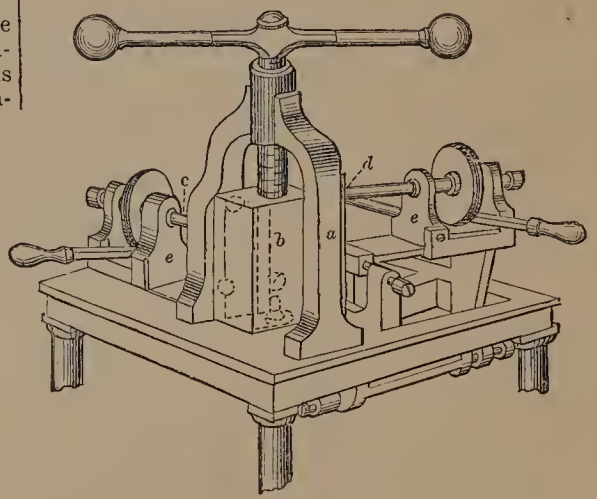
The *boring-machine* for block-making consists of an iron frame *a*, in which the *juggle b* is clamped by a screw, which confines it while the borers *c d* act upon it. These borers are center-bits, and act at right angles to each other, — *c* to form the hole for the sheave-pin, and *d* to form a commencement for the mortise to contain the sheave. Each bit is fixed in a lathe-head *e e*, and driven by a band. The head slides upon ways, so as to feed up to the work, being advanced by a lever. The ways have a certain lateral and vertical adjustability so as to work at the required angle and hight.

Fig. 819.



Carpenter's Boring-Machine.

Fig. 820.



Boring-Machine.

Bor'ing-ta'ble. The platform of a boring-machine on which the work is laid.

Bor'ing-tool. (*Metal-working.*) A cutting-tool placed in a cutter-head to dress round holes.

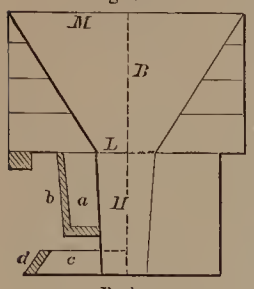
Bort. (*Diamond-cutting.*) Small fragments of diamond, split from diamonds in roughly reducing them to shape, and of a size too small for jewelry. Bort is reduced to dust in a mortar, and used for grinding and polishing.

Bo'shah. (*Fabric.*) A Turkish-made silk handkerchief.

Bosh'es. (*Metallurgy.*) The sloping sides of the lower part of a blast-furnace, which gradually contract from the belly, or widest part of the furnace, to the hearth.

In a furnace 55 feet high and 38 feet wide at the base of the structure, the boshes will be 8 feet in perpendicular hight, 12 feet wide at top (*M*), and 2½ feet at the bottom (*L*), where they join the hearth. The boshes are built of a coarse-gritted freestone, abounding in small nodules of quartz.

Fig. 821.



Boshes.

The cut represents the *hearth H* and *boshes B* in a vertical side-section. *a* is the *tymp-stone* and *b* the *tymp-plate* for confining the molten metal in the hearth. This plate, in connection with the protecting stone *a*, forms the front of the hearth, and is firmly wedged into the side-walls thereof. *c* is the *dam-stone* which occupies the whole breadth at the bottom of the hearth, excepting about six inches, which space, when the furnace is at work, is filled before every cast with a strong binding sand. This stone is faced outside by a strong cast-iron plate *d*, called a *dam-plate*. The space under the *tymp-plate* is rammed full, for every cast, with strong, loamy earth or fine clay, — a process called *tymp-stopping*.

A number of newly invented puddling and boiling furnaces have iron floors and boshes. A current of water is caused to circulate in them to prevent destruction of the iron under the extreme heat.

Baker's *puddling-furnace* has a hollow cast-iron bed-plate and bosh, through which water is conducted.

Williams's *furnace* has hollow bridges with air-chambers and water-boshes.

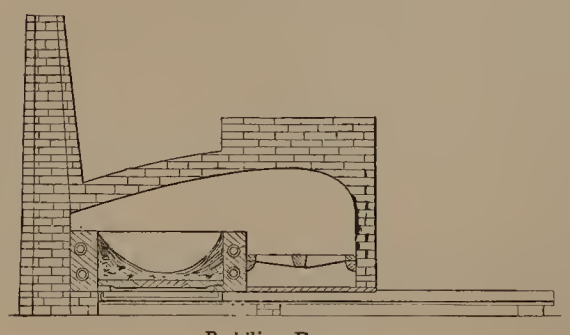
Hall's *furnace* has fire-brick around the iron bed against which jets of water are injected from tubes.

Snyder's *furnace* has a wrought-iron bed-plate with brick boshes.

Whipple's *furnace* has a double bottom of iron. The lower plate is corrugated. Water conducted into the hollow bed and boshes is converted into steam and conducted away.

In Fig. 822 the bosh is cast upon wrought-iron pipes which will afford circulation for water to cool and preserve the bosh. The water-chamber beneath

Fig. 822.



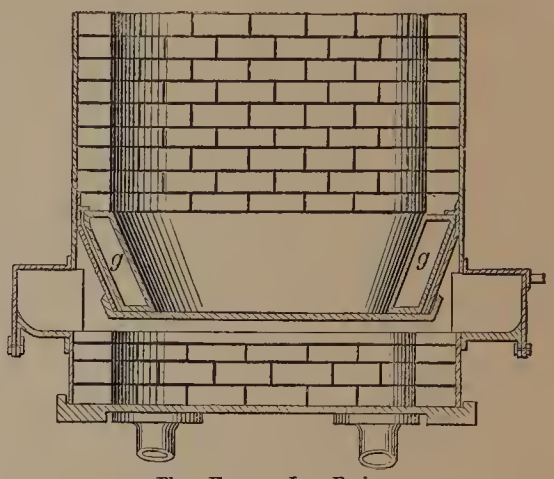
Puddling-Furnace.

has the same effect. The front plate is attached by tongues and grooves to the bosh, and the fore-plate similarly attached in the front plates.

The material which is banked up against the boshes to protect them from the heat is called *fixing*. It consists of scrap and ore, and receives a preliminary melting. One *composition for fixing* furnaces consists of finely pulverized ore and German clay made into a paste; and another for the same purpose is a paste made by grinding the ore and rendering it plastic by moistening and working. *Bull-dog* (Fr. *trochi*) is a decomposed protosilicate of iron used in England and France for this purpose.

Grout's *cupola and blast-furnace*, instead of fire-brick lining to the hearth, has hollow cast-iron boshes united by flanges, forming chambers *g*, so arranged that a current of cold water may flow

Fig. 823.



Blast-Furnace Iron Boshes.

through them, dispensing with an internal lining of fire-brick or other refractory substance.

These chambers are so arranged that they may be removed without disturbing the superior brick-work.

Bo'som. (*Milling.*) A recess or shelving depression round the eye of a mill-stone.

Bo'som-fold'er. A plaiting machine or device for laying a fabric in flat folds, suitable for a shirt-bosom.

Boss. 1. (*Machinery.*) *a.* An elevated or thickened portion, usually around an aperture.

b. A swage or stump used in shaping sheet-metal.

2. (*Architecture.*) In Gothic architecture, the protuberance in a vaulted ceiling formed by the junction of the ends of several ribs, and serving to bind them together; usually elaborately carved and ornamented.

3. (*Masonry.*) *a.* A mortar-bucket slung by a hook from the round of a ladder.

b. A short trough for holding mortar. Hung from the laths and used in tiling a roof.

4. (*Saddlery.*) The enlargement at the junction of the *branch* of a bridle-bit with the mouthpiece.

5. (*Ordnance.*) A plate of cast-iron secured to the back of the hearth of a traveling-forge.

6. (*Bookbinding.*) A metallic ornament on a book side to receive the wear.

Bos'sage. (*Architecture.*) Projecting stones, such as quoins, corbels, roughed out before insertion, to be finished *in situ*.

Bos'sing. (*Porcelain.*) *Ground-laying* the surface of porcelain in an unfinished state, to form a basis of adherence for the color, which is deposited by the *pencil*, by *cotton-wool*, or by *stencil*, according to the mode. The *bossing* is a coat of boiled oil, to hold the color. The oil is expelled by the heat of the enamel-kiln, and the color vitrified.

The *bossing* is laid on with a hair-pencil, and leveled with a *boss* of soft leather.

Bott'ger-ware. The white porcelain of Dresden. Made originally by Bottger, of Saxony, in imitation of the Chinese. It is now made in the old castle, once the residence of the Saxon princes, at Meissen on the Elbe, 15 miles below Dresden.

Bott-ham'mer. (*Flax.*) A wooden mallet with a fluted face, used in breaking flax upon the floor to remove the *boon*.

Bot'ting. (*Metallurgy.*) Restopping the *tapping-hole* of a furnace after a part of its charge has been allowed to flow therefrom. The plug is a conical mass of clay on the end of a wooden bar.

Bot'tle. A vessel with a relatively small neck, and adapted to hold liquids. In ancient times they were made of leather. The Psalmist declares he has "become like a bottle in the smoke," that is, shriveled and wrinkled. It is also advised by the Savior, — a metaphysical meaning being couched in the words, — not to put new wine into old bottles, as they could not withstand the action of fermentation.

The skin-bottles of the East are made of goat-skins; when the animal is butchered, its head and feet are cut off, and the skin drawn off without ripping. In Arabia it is tanned with acacia bark, the hair being left on the outside. The several openings are sewn up, and the neck, which serves as a spout, is tied. Such bottles were used by the Greeks, Egyptians, and Romans, being mentioned by Homer, Herodotus, and Virgil. They are also used to the present day in Spain and Sicily, and other Mediterranean countries; they are called *borrachas* in Spain, and the peculiar flavor of marsala and some other wines is attributed to the skins in which they were originally brought to market.

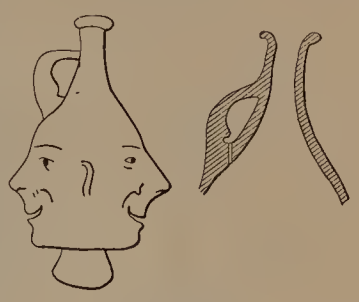
Bottles of earthenware are usually made with handles, and are called flasks. Cast-iron bottles, closed by a screw-plug, are used for holding quicksilver. Glass is, however, the material almost universally employed in the bottle manufacture. It is generally of the coarsest and commonest kind, made from inferior materials; in fact, the use of any others for the purpose was prohibited in England until a comparatively recent period. Six persons are employed in the necessary manipulations; one of whom

Fig. 824.

Skin-Bottles.

dips the red-hot end of an iron tube into the pot of molten glass, turns the rod around so as to surround it with glass, lifts it out to cool a little, then dips and turns it around again, and so on until he has collected a ball of sufficient size to form the required bottle. He then hands it to the blower, who rolls the plastic lump of glass on a smooth stone or cast-iron plate until he brings it to the very end of the tube, forming a pear-shaped lump, when he introduces it into an open brass or east-iron mold, which he shuts together by pressing a pedal with his foot, and, holding the tube vertically, blows through it, expanding the glass so as to fill the concavity of the mold. Upon removing his foot from the pedal the two halves of the mold open, turning upon a hinge at the bottom. The bottle is then removed and handed to the finisher, who, by touching the tubular neck of glass by which the bottle adheres to the pipe, cracks it off smoothly at the mouth; the finished bottles are then placed in the annealing-furnace and allowed to cool slowly for twenty-four hours or more.

Fig. 825.



Peruvian Bottle.

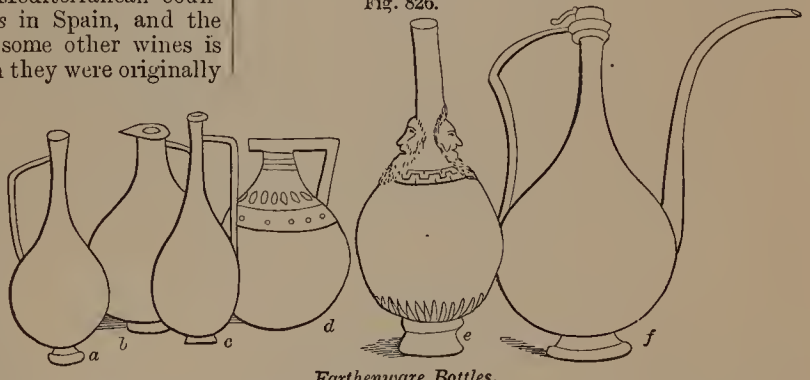
This kind of mold produces a seam down each side of the bottle, causing a rather unsightly appearance. See GLASS.

Glass bottles were known to the Romans of the Empire, and are found in Pompeii.

A glass bottle with a capacity of 112 gallons was blown at Leith, in Scotland, about 1747.

Fig. 825 shows an earthen bottle from Peru, with two faces. The sectional view shows the shape of the neck and handle.

Fig. 826.



Earthenware Bottles.

Fig. 826 shows a number of ancient bottles.

a b c are from Thebes.

d is Etruscan.

e is from China.

f from ancient Egypt.

Bot'tle-boot. A leather case to hold a bottle while corking.

Bot'tle-brush'ing Ma-chine'. A device for cleansing the interior of bottles. The brushes, fixed on a rotating shaft, are inserted into the bottles, and rotation imparted by means of the treadle *b*. The operator may take a bottle in each hand, cleansing two at once.

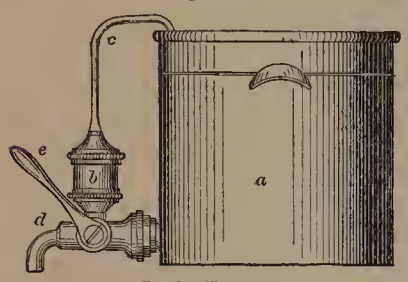
Fig. 827.

Bottle-Brushing Machine.

Bot'tle-case Loom. A machine in which the wicker cover is placed upon demijohns and carboys. This is, however, almost entirely done by hand, and is the work of a basket-maker.

Bot'tle-charg'er. An apparatus for charging bottles with a liquid under pressure, as, for instance, with air containing carbonic acid, and with a graduated amount of syrup. *a* is the vessel containing the aërated water; *b* the syrup-cup; *c* a pipe equalizing the pressure in the vessels *a* and *b*. The size of the opening leading from the cup *b* to the common nozzle *d* is adjustable, and *e* is the handle of the faucet by which the liquid is discharged.

Fig. 828.



Bottle-Charger.

Fig. 829.

Bottle-Faucet.

Bot'tle-fau'cet. A faucet adapted to the uses of a bottle, as in the illustration, where it has a threaded hollow stem to transfix the cork.

Bot'tle-fill'er. See BOTTLING-APPARATUS.

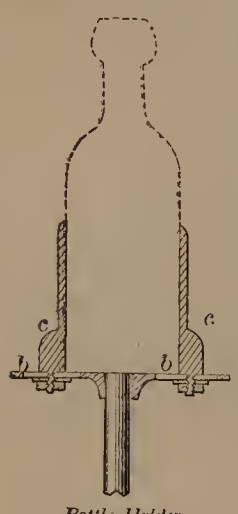
Bot'tle-glass. Bottle-glass is composed of cheap sand and alkali, and the manufacture has nothing special about it. Bottles were formerly made by blowing and rolling, but since the introduction of presses, blowing and molding have been combined. The mass of molten glass at the end of the tube (*pontil*) is inserted in an iron mold, which gives the external form, while the hollowness is produced by blowing through the tube.

The alkalies used are wood ashes and common salt. Common sand, gas lime, clay, and the refuse lime and alkali after the manufacture of soap, enter into the composition of *frit* for bottle-glass.

Beer and wine bottles are blown in a mold. Carboys are blown by the aid of steam, which is produced by spirting a mouthful of water through the blowing-tube, the end of the tube being covered by the thumb.

Bot'tle-hold'er. An adjustable tool for grasping the bottle by its base while finishing the top.

Fig. 830.



Bottle-Holder.

The disk *b* is attachable to the punty-rod, and slotted radially to receive the clamps *c c*, which are adjusted to various sizes of bottles; the inner faces of the clamps may be either flat or curved, to suit them to hold bottles of varying shapes and sizes.

See cut under GLASS.

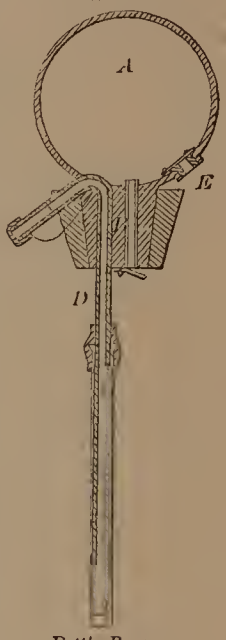
Bot'tle-jack. 1. (*Culinary.*) A roasting-jack of a bottle shape, suspended in front of a fire, and giving a reciprocating rotation to the meat which depends therefrom. It is operated by clock-work mechanism.

2. A form of lifting-jack, so called from its resembling a bottle in shape.

Bot'tle-mold'ing. (*Glass.*) A process adopted with most kinds of merchantable bottles of staple kinds. The bulb of glass on the end of the blow-tube is partially expanded, and then placed between the parts of an iron mold which is open to receive it. The parts are closed and locked, and the bulb then expanded by the breath to completely fill the mold.

In 1822, Rickets, of Bristol, England, obtained a patent for a bottle-molding apparatus, comprising a frame for holding and operating a bottle-mold. The mold consisted of a die for forming the body of the bottle, a two-part die for forming its top, and a plunger for shaping its bottom; these are reciprocated by means of treadles and levers. The frame is adapted to be used with dies of various sizes and shapes. The molten glass is blown out, so as to fill the mold in the ordinary way.

Fig. 831.

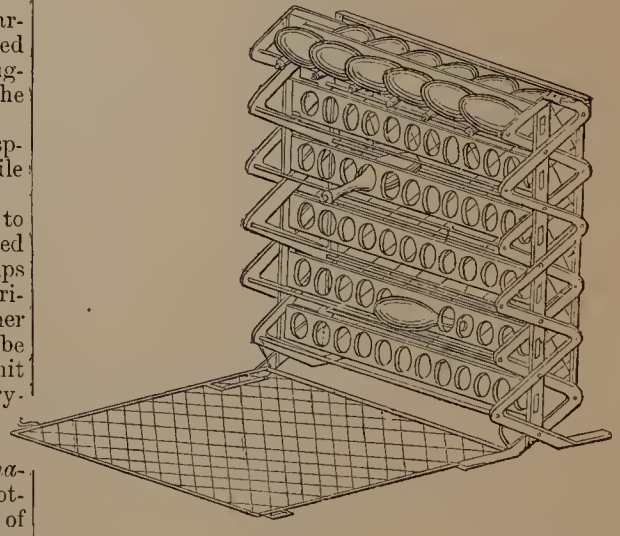


Bottle-Pump.

Bot'tle-pump. A device for withdrawing the fluid contents of a vessel without pouring. That illustrated comprises an elastic bulb *A*, having air induction and eduction apertures *E B*, provided with valves and a curved pipe *D*, whose longer branch is inserted into the neck of the bottle, the orifice of which is closed by the plug *B*. Compressing the elastic bulb drives air into the bottle, and expels the liquid through the pipe and nozzle.

Bot'tle-rack. The rests are so arranged that by inserting the bottles alternately neck and butt, a greater number may be stored within a given space. The hinged frame is for the purpose of securing the bottles in place during transportation.

Fig. 832.



Bottle-Rack.

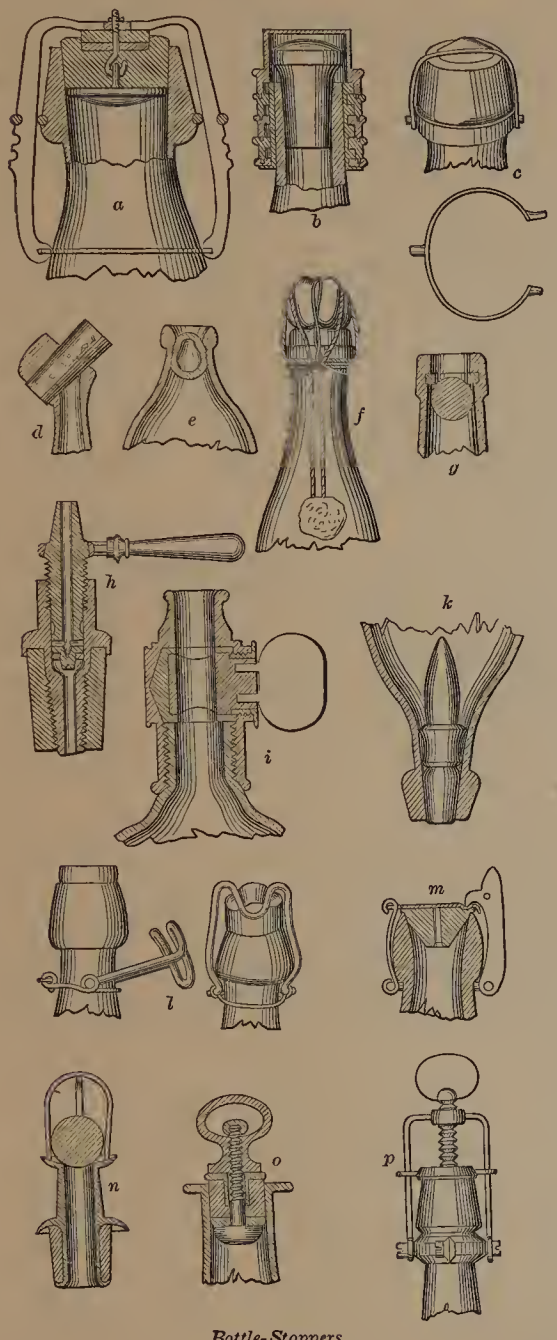
Bot'tle-screw. A corkscrew.

Bot'tle, Si'phon. A bottle having a tube which discharges the contents by a pipe which reaches nearly to the bottom, so as to eject liquid, as long as any remains, unmixed with the air. See Figs. 46, 48, pp. 18, 19.

Bot'tle-stop'per. A device for closing the mouths of bottles. It usually consists of a cork and a means of holding it in place against the pressure of the bottle's contents.

In some cases a composition is substituted for the cork.

Fig 833



Bottle-Stoppers.

a has a bail carrying the stopper, and the spring arms, which are permanently fixed in an annular recess in the swelling of the bottle-neck, catch into notches of the bail, and hold it and the stopper securely.

b is a permutation-lock stopper, set on a given combination, and holds a cap over the stopper.

c is a hinged bail, which is attached to a ring on the neck. The latter has a divided section which allows it to open.

d has a diagonal opening through the neck of the bottle. The pressure of the gas is upon the side of the cork, and does not tend materially to expel it. The cork may be ejected by a push, without a corkscrew.

e is a hollow rubber ball, driven by the pressure of gas against the inside of the neck. Removed by pressure of a rod, and floats on the liquid.

f is a method of tying champagne corks.

g is a bottle having a neck molded with an interior annular recess, filled by a packing-ring against which a glass ball is sustained by pressure of the gas.

h is a screw-faucet which has a packing against the lower end, which is depressed against a seat.

i is a simple bottle-faucet or one-way cock. It is opened by a key.

k is a glass rod which carries a packing around its enlarged head; one of its tapering ends guides it into its position in the neck of the bottle.

l is a hinged wire bail bent into U-form, so as to be swung up on to the cork while the latter is held by the plunger of the bottling-machine.

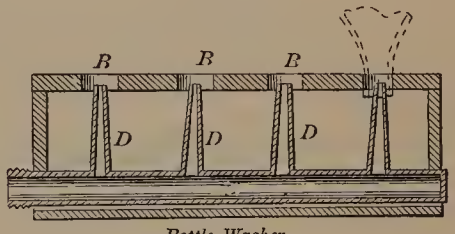
m is a rubber stopper, hinged on one side, and held on the other by a catch.

n is a glass ball, seated on the lip by gravity, and restrained by a cage when the bottle is tilted to discharge the liquid.

o is a stopper of rubber compressed between two disks brought together by a screw, and thus expanded against the inside of the neck.

p is a bail hinged by a collar around the bottle-neck, and having a screw which compresses the rubber-faced cap.

Fig. 834.

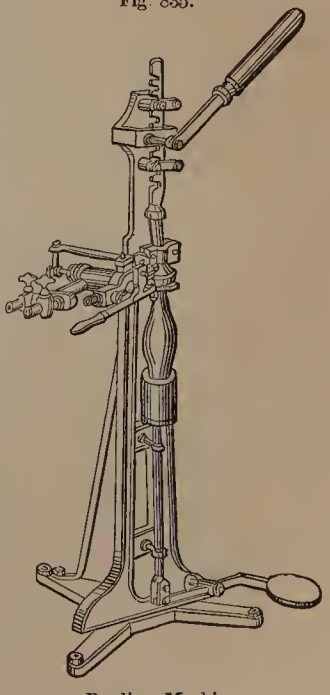


Bottle-Washer

Bot'tle-wash'er. A device for cleansing the interior of bottles. The example consists of a table having apertures *B* for the insertion of the necks of the bottles, into which water is forced by means of pipes provided with nozzles *D*.

In another form of the machine the bottles are placed in a horizontal position between base-plates coated with india-rubber and stoppers of the same material. Being previously about one third filled with shot, eight bottles are arranged in a circle around a horizontal spindle, and eight more in a second group around the same spindle. A rapid reciprocating motion is then given to the spindle, which also turns on its axis, so as to bring all parts of the

Fig. 835.



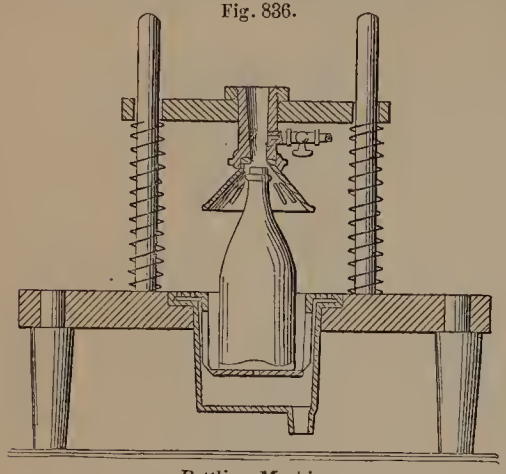
Bottling-Machine.

bottle successively into the lowest position. Thus 16 bottles are washed at once, and at the rate of 45 gross per day. An enlarged form of the machine is used for kegs and barrels.

Bot'tling-ma-chine'. A machine for filling bottles and corking them. The example (Fig. 834) is constructed to fill with soda-water or with soda-water and syrup combined. It first injects a graduated amount of syrup into the bottle, and then the water.

In Fig. 836 is shown a bottling-machine in which the bottle stands in a metallic cup, and the lip is

Fig. 836.



Bottling-Machine.

centered by the pressure upon it of an inverted funnel, depressed by a spring. The liquid is introduced at the faucet, and the cork is driven in through the vertical tube.

Bot'tling-pli'ers. Pliers specifically adapted for fastening wires over the corks and necks of bottles and for cutting off the surplus.

Bot'tom. 1. (*Fort.*) A circular disk with holes to hold the rods in the formation of a gabion.

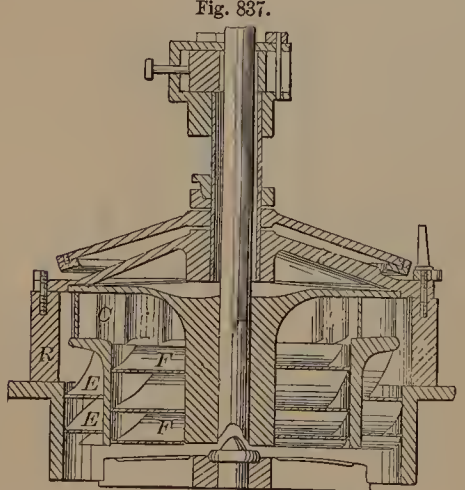
2. (*Shipwrighting.*) The planks forming the floor of a ship's hold.

3. (*Ordnance.*) One of the plates by which grape or canister is built up into a cylinder suitable for loading into the gun. Cast-iron tops and bottoms for grape; wrought-iron for canister.

4. (*Machinery.*) Cogs are said to *bottom* when their tops impinge upon the periphery of the co-acting wheel.

A piston which strikes or touches the end of its cylinder is said *to bottom.*

Fig. 837.



Downward-Discharge Water-Wheel.

Bot'tom-dis'charge Water-wheel. A turbine from which the water is discharged at the bottom instead of at the sides. In that illustrated, the stream is admitted horizontally at the sides into the vertical buckets *C*, through which it passes, and then acts while descending upon inclined buckets *F*. The lower flow descends over the inclined buckets *E* at the periphery of the wheel. The balanced gates *R*, for admittance of water, are opened by segmental racks on their shafts, which engage with similar racks on an upper wheel.

Bot'tom-heat. Artificial temperature beneath the surface of the soil in a forcing-house.

Bot'tom-ing. 1. (*Civil Engineering.*) The foundation of a road-bed.

2. (*Railroad Engineering.*) Ballasting beneath and around ties.

Bot'tom-ing-hole. (*Glass-making.*) The open mouth of a furnace at which a globe of *crown glass* is exposed during the progress of its manufacture, in order to soften it and allow it to assume an oblate form.

Bot'tom-lift. (*Mining.*) The deepest lift of a mining-pump, or the lowest pump.

Bot'tom-plate. (*Printing.*) A plate of iron belonging to the mold of a printing-press, on which the carriage is fixed.

Bot'toms. 1. (*Mining.*) The deepest workings.

2. (*Metallurgy.*) Heavy and impure metallic products of refining, found at the bottom of the furnace in some of the stages of the copper-smelting processes.

Bot'tom-tool. (*Wood-turning.*) A turning-tool having a bent-over end, for cutting out the bottoms of cylindrical hollow work.

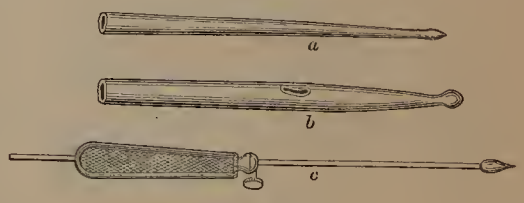
Bouche. A cylinder of copper in which the vent of a piece of ordnance is drilled. It has an exterior screw-thread cut on it, so that it may be removed when the vent becomes worn, or a new bouche substituted.

Bouch'ing. The gun-metal bushing of a block-sheave around the pin-hole.

Bouge; Bowge. (*Nautical.*) A rope fastened to the middle of a sail to make it stand closer to the wind.

Bou-gie'. (*Surgical.*) A smooth, flexible, elastic, slender cylinder, designed to be introduced into the urethra, rectum, or œsophagus, in order to open or dilate it in cases of stricture or other diseases.

Fig. 838.



Bougies.

The slenderer forms of bougies are adapted for the *urethra*, the larger for the *rectum*, *vagina*, and *œsophagus*. They are said to have been invented by Aldereto, a Portuguese physician, and were first described by Amatus, one of his pupils, in 1554. They are made either solid or hollow, and are sometimes medicated. Pickel, a French medical professor, gives the following recipe for their manufacture: 3 parts of boiled linseed-oil, 1 of amber, and 1 of oil of turpentine, are to be melted and well mixed together, and spread at three successive intervals upon a silk cord or web. The pieces thus coated are then to be placed in a stove heated to 150° F., and allowed to remain for 12 hours, 15 or 16 fresh layers of the compositon being

added in succession until the bougies are brought to the required size. They are next polished with pumice-stone, and afterwards smoothed with tripoli and oil. In Paris, which is the chief seat of the manufacture of these articles, one seventh of its weight of caoutchouc is dissolved in the oil, to render the compound more solid. For this purpose the caoutchouc is cut into slender filaments and added to the hot oil. Each successive layer is first dried in a stove, and then in the open air, before another is applied. For the best, or *elastic* bougies, the process requires two months for its completion; these should bear twisting around the finger without cracking or scaling, and be capable of stretching without giving way, but retract on being let go.

For hollow bougies an iron wire is introduced into the axis of the silk tissue, and withdrawn when the bougie is finished. Some are made with a hollow axis of tin foil rolled into a hollow tube. They are also made entirely of caoutchouc, dissolved in sulphuric ether.

An *armed bougie* is one with a piece of caustic fixed in its extremity.

HUNTER'S bougie is a rolled piece of soft linen dipped, previous to rolling, in a composition of

Yellow wax	2
Red lead	3
Olive-oil	6

Finish off on a polished slab.

Caoutchouc bougies are made by applying a solution of india-rubber to the silk cord.

Gutta-percha bougies must be made of the best material, as their breaking *in situ* may prove fatal. It is better to use a silk cord, covered with the desired composition.

OTIS'S *bougie à boule* (*c*) has a rounded and elongated head fixed on the stem, which slides through a handle and is held fast by a set screw.

a is an ordinary bougie.

b a bulbous bougie.

Boul'der-head. (*Hydraulic Engineering.*) A work of wooden stakes to resist the encroachment of the sea.

Boul'der-ing-stone. (*Metal-working.*) A smooth flint stone, used by cutlers to smooth down the faces of *glazers* and emery-wheels.

Boul'der-pav'ing. Paving with round water-worn boulders, set on a graded bottom of gravel.

Boul'der-wall. (*Masonry.*) One made of boulders or flints set in mortar.

Boul'tine. (*Architecture.*) A convex molding, whose periphery is a quarter of a circle, next below the plinth in the Doric and Tuscan orders.

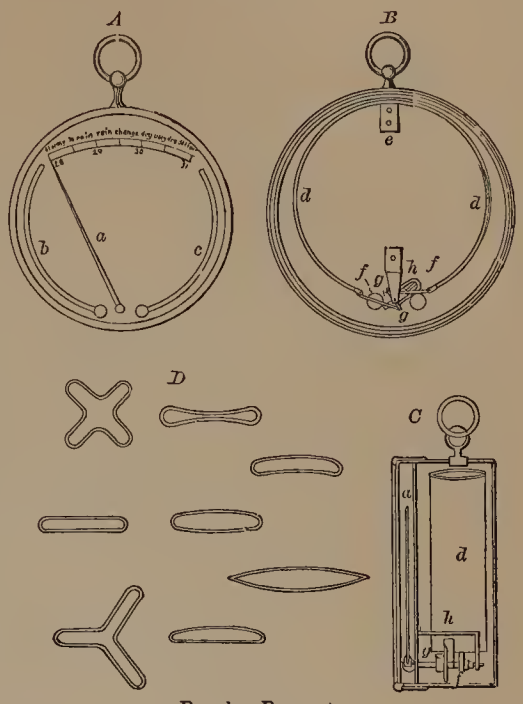
Bound. The path of a shot comprised between two *grazes*. See RICOCHET-FIRING.

Boun'da-ry-line. (*Shipbuilding.*) The trace of the outer surface of the skin of a ship on the stem, keel, and stern-post. It corresponds with the outer edge of the rabbet in those parts of the structure.

Bour'don Ba-rom'e-ter. The metallic barometer invented by Bourdon, of Paris, 1849, consists of an elastic flattened tube of metal bent to a circular form and exhausted of air, so that the ends of the tubes separate as the atmospheric pressure is diminished, and approach as it increases.

In Fig. 839, *A* is a front view, showing the hand or indicator *a* and the scale; *b* and *c* represent ordinary mercurial thermometers attached to the face. *B* is a back view, showing *d*, the tube, secured at its middle *e*, and having its ends connected by links *f f* to two short levers *g g*, on the same axis as the hand *a*, and operating, by means of the link-connections, to multiply its motion as the ends of the tubes

Fig. 839.



Bourdon Barometer.

approach or recede. *h* is an open plate which may be sprung apart, so as to allow the adjustment of the levers and hand to any particular range.

C is a transverse vertical section.

D represents sections of various tubes which may be employed.

The more approved forms of steam and vacuum gages are now constructed on this principle.

The *Bourdon* is commonly known as the *metallic barometer*, although the *aneroid* is also metallic, and both *holosteric*.

Bour-geois'. (*Printing.*) A size of type between *Brevier* and *Long Primer*.

Brevier, 112 ems to the foot.
Bourgeois, 102 ems to the foot.
Long Primer, 90 ems to the foot.

Bou-tant'. (*Architecture.*) An arc-boutant is an arch or buttress serving to sustain a vault, and which is itself sustained by some strong wall or massive pile. A flying-buttress.

Bow. 1. (*Archery.*) An instrument for projecting an arrow. It consists of a strip of wood or other material, the ends connected by a string. The bow is bent by retraction of the string, and the recoil imparted to the latter projects the arrow. In its simple state, and when large enough to be used for military purposes or for destroying large animals, it is known as the long-bow; when mounted transversely in a stock, it is a cross-bow. The former is exclusively adapted for shooting arrows; while bolts, or even round projectiles, may be thrown by the latter.

The long-bow, owing to its greater portability and capability of rapid discharge, was a much more effective weapon than the cross-bow, and continued in use for a long time after the introduction of fire-arms. The English archers, like the Egyptians in the time of Rameses the Great, were taught to draw the arrow to the ear, instead of to the shoulder, as was the practice elsewhere, and hence constituted a most effective species of force almost unknown in the other armies of Europe. 220 yards from the butt or target

was the smallest distance allowed for practice by a full-grown man, according to the English archery-statutes. The cross-bow, as used by the Genoese, whose archers were in high repute in the Middle Ages, was a cumbrous and heavy weapon bent by a small windlass, and incapable of rapid loading and discharge.

For illustrations see "Iconographic Encyclopedia," "Frost's Pictorial History"; and for descriptions see "Gibbon's History" and other works treating of ancient and mediæval military tactics and weapons.

The use of the bow is of great antiquity. Plato credits Apollo with the invention. Ishmael became an archer (Gen. xxi. 20). The Philistine archers overcame Saul (1 Sam. xxxi. 3). David commanded it to be taught (2 Sam. i. 18). Aster of Amphipolis shot Philip of Macedon, and was hanged therefor. An ancient Egyptian bow is preserved in the Abbott Museum, New York, together with the leather case that contained it and fastened it to the war-chariot. Four arrows, made of reed and tipped with flint-stone, are suspended with it.

The Scythian bow was remarkable for its great curvature, being nearly semicircular.

The Lycian bow was made of the cornel-tree; those of the Ethiopians of the palm-tree. The horn of the antelope was used in the East for bows, at least as far back as the siege of Troy, and is still employed for the purpose. The English long-bow was made of yew or ash.

The Indian contingent of the army of Xerxes had bows of cane and arrows of cane with iron points. They wore cotton dresses. (Herodotus vii. 65.)

The arrow-heads of the Ethiopians were of agate and other siliceous stones. "Pieces of stone of the kind used in engraving seals."— *Ibid.*

The bows of the Ethiopians were of the stem of the palm-leaf.

Pliny says: "It is by the aid of the reed that the nations of the East decide their wars. Fully one half of mankind live under a dominion imposed by the agency of the arrow." The Eastern reed, so called, was a bamboo.

Harold, William Rufus, and Richard I. were killed by arrows. Crecy, Poictiers, and Agincourt were won by archers. The long-bow of that time measured six feet, the arrow three feet. The range was 300 to 500 yards.

In the Southwest of England bows and arrows did not finally disappear from the muster-roll till 1599. The muskets were such miserable affairs that in the middle of the fifteenth century it took fifteen minutes to charge and fire one.

2. (*Husbandry.*) The bent piece which embraces the neck of an ox, the ends coming up through the yoke, above which they are fastened by a key.

3. (*Machinery.*) An elastic rod and string for giving reciprocating rotation to a drill. See BOW-DRILL.

4. (*Drawing.*) An elastic slip for describing curves. An *arcograph.*

5. (*Hat-making.*) A piece of elastic wood, six feet long, and having a catgut string stretched between its extremities. The vibrating string operates upon the felting-hair on a grid called a *hurdle*, lightens up the fibers, assembles them into a bat, and drives out the dust. See BOWING.

6. (*Masonry.*) A projecting portion of a building of circular or multangular plan.

The bow-windows of English domestic architecture are known as *oriels.*

7. (*Vehicles.*) A bent slat to support the hood, canopy, cover, or tilt of a vehicle; otherwise called a *slat.*

8. (*Music.*) A number of long horse-hairs stretched upon an elastic rod, and used to vibrate the strings of instruments of the viol class.

9. (*Lock.*) The loop of a key which receives the fingers.

10. (*Weapon.*) The arched guard of a sword-hilt or of the trigger of a fire-arm.

11. (*Saddlery.*) The arched forward part of a saddle-tree which straddles the horse's back.

12. (*Nautical.*) An old nautical instrument for taking angles. It had one large graduated arc of 90°, three vanes, and a shank or staff. — ADMIRAL SMYTH.

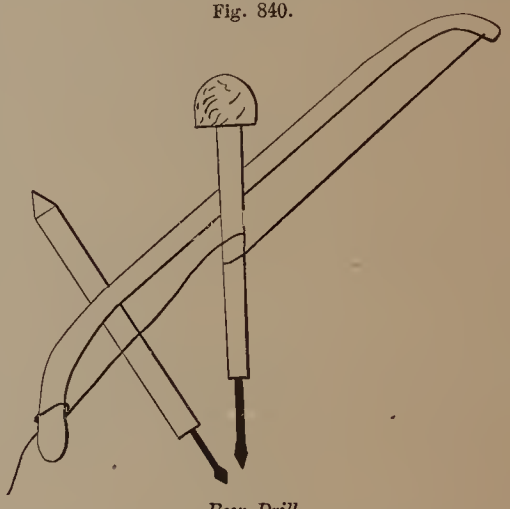
Bow. The fore end of a ship or boat.

Bow-com'pass. (*Mathematical Instrument.*) For drawing curves of large radius. It consists of a pliable strip which is bent by screws to any curve. An *arcograph.*

Bow-drill. A drill operated by means of a bow, the cord of which is given one or more turns around the handle of the drill, and alternate revolution in opposite directions imparted to it by alternately reciprocating the bow backward and forward.

The most ancient drill of which we have any authentic representation is the bow-drill. The annexed cut is from a painting in a tomb at Thebes, where one drill is shown in its detachable socket, and another one disconnected. So much pains did the artist

Fig. 840.

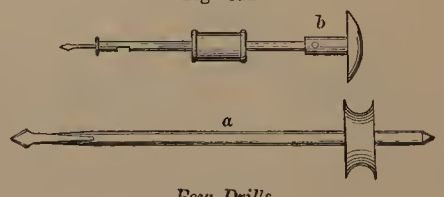


Bow-Drill.

take to make all plain to the comprehension of the spectator of future ages. It was for such they were painted, as the tombs themselves were occupied by the mortal remains which they expected to be again tenanted by the same mind and soul.

The various tools employed in chair-making are shown in the hands of the workmen or hanging on the wall. The saw and the adze were the principal shaping-tools. The parts of the chair were secured together by tenon and mortise, fastened by wooden pins. See the chairs in Dr. Abbott's collection, New

Fig. 841.

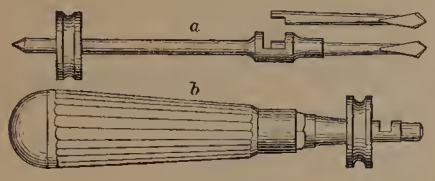


Bow-Drills.

York Historical Society's Museum. The same collection has drill-bows and cords from Sakkarah and elsewhere.

The modern bow-drill is shown in Figs. 841, 842. *a* in each figure is designed to have a back-center in one of the holes in the end of the vise-cheek, in which case the work is held in the left hand and the bow

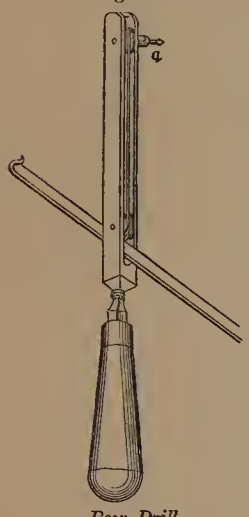
Fig. 842.



Bow-Drills.

in the right ; or the drill-stock may have a handle *b* which is grasped in the left hand, pressing the drill upon the work, which is on the bench or in the vise, while the bow is operated by the right hand.

Fig. 843.



Bow-Drill.

Freeman's drill, instead of a bow, has a flat strip of wood with a facing of india-rubber, which has sufficient frictional adhesion to the wooden pulley on the drill-stock to rotate it by pressure, when the flat strip is reciprocated like a violin bow.

Fig. 843 shows a pair of pulleys driven by a catgut cord as the bow is reciprocated. The bow-string is wound around one of the pulleys, and the axis of the other is a stock which holds the drill *a*, and enables it to be presented at right angles to the length of the stock.

Bow'er. (*Nautical.*) The usual working-anchors at the bow, known as *best* and *small* ; not from any difference in size, but according to position. The *starboard* is the *best* ; the *port*, the *small*.—Admiral Smyth.

Bow-fast. (*Nautical.*) A hawser at the bow, whereby a ship is secured alongside a wharf or other object.

Bow-file. A curved file. A *Riffler.*

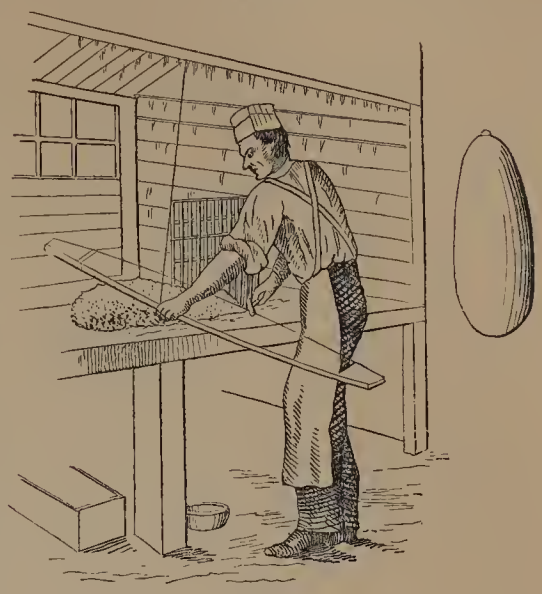
Bow-grace. (*Nautical.*) Or *Bon-grace.* A fender made of junk and ropes, lapping around the bow as a protection against floating ice.

Bow'ie-knife. A weapon used in the South and Southwest, and named after the inventor, who had a taste in that direction, and strongly insisted upon its superiority to the ordinary stiletto.

Bow'ing. (*Hat-making.*) A mode of separating the filaments of felting-fur, and distributing them lightly in an openwork frame, called a *basket.* The oval sheet of fur thus obtained is worked by pressure, and a rubbing jerking motion, which causes the fibers to interlace (felt), so that the sheet of napping can be handled and shaped by the succeeding processes.

In *bowing*, the amount of fur is weighed out, placed in a wad on the bench, and, the bow being held over it, the string is twanged by a wooden pin in the hand of the workman, so as to pick up a quantity of the filaments at each vibration, and throw them on to the *basket*, or wire screen.

Fig. 844.



Bowing.

Bow-in'stru-ments. (*Music.*) A term including that class of stringed instruments which are played by means of a bow. The violin, violoncello, double bass, etc.

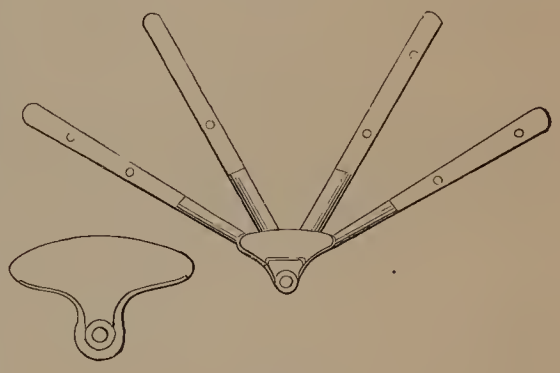
Another class of stringed instruments is played by the fingers or plectrum ; as the guitar, harp, harpsichord, etc.

Another class is represented by the piano-forte and dulcimer, the strings being vibrated by a hammer.

Another by the air ; as the æölian.

Bow-i'ron. (*Vehicle.*) The staple on the side

Fig. 845.



Bow-Iron.

of a wagon-bed which receives the bows of the tilt or cover, as in Fig. 845.

Bowk'ing. The process of boiling in an alkaline lye in a kier. *Bucking.*

Bowl. (*Knitting-machine.*) A roller or anti-friction wheel, on which the carriage traverses. A *truck*, in Nottingham parlance.

1. An open vessel of segmental or frusto-conical form, for containing liquids ; larger and proportionately less deep than a cup.

"The Thibetans have no porcelain, but their potteries are, nevertheless, of great excellence. The wooden bowls, which every one carries, are made of the root of certain trees which grow on the mountains of Thibet. They are of a simple but elegant form, and have no other decoration than a slight coating of

varnish, which does not hide either the natural color or the veins of the wood. Some of these bowls may be purchased for a few pence, and others are valued at one hundred ounces of silver. . . . . To us they seemed all alike. . . . . They say that some have the power of neutralizing poisons." (Abbé Huc's "Travels in Tartary," etc.) Each Tartar carries his bowl in the bosom of his robe.

2. The hollow open part of anything, as of a spoon, a tobacco-pipe, etc.

3. A ball; more particularly, a large wooden ball used in the sport of bowling.

Bow'line. (*Nautical.*) A rope connected by *bridles* to the middle of the *leech* of a square sail, and passing forward, so as to keep the weather-edge of the sail well forward when sailing *close-hauled*, and enable the ship to come nearer to the wind. *On a bowline:* sailing close or *close-hauled.*

Bow'line-bri'dle. (*Nautical.*) The span which connects the bowline to several cringles on the leech of a square sail.

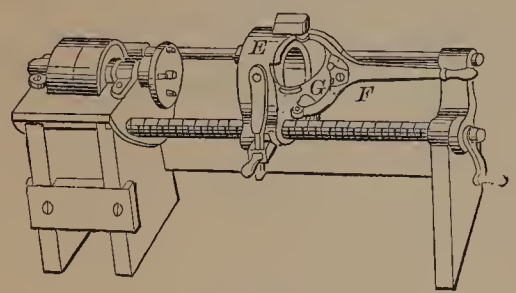
Bow'line-knot. (*Nautical.*) A peculiar knot by which bowline-bridles are fastened to the cringles. See KNOT.

Bow-lines. (*Shipbuilding.*) Curves representing vertical sections of the bow-end of a ship.

Bowl-ma-chine'. A machine for making wooden bowls.

The solid cylindrical blank is clutched by the rear end in the lathe, and its forward end turns in the

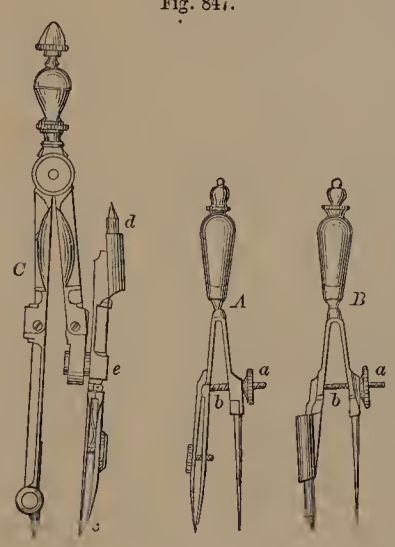
Fig. 846.



Bowl-Machine.

cylindrical rest *E*, which is adjustable longitudinally, and gives fulcrum-bearing to the lever *F* carrying the curved cutting-tool *G*. The blank is rotated and the bowl cut by sweeping the lever around a curve of 90°. The necessarily increased thickness of the bottom gives opportunity to remove a plano-convex disk to form a flattened bottom.

Fig. 847.



Bow-Pen.

Bow-net. (*Nautical.*) A lobster-trap made of two round wicker-baskets, one thrust within the other, and having a lip to oppose the return of the fish.

Bow-pen. (*Mathematical Instrument.*) A form of compasses for the finer and more minute parts of mechanical and architectural drawing. The legs are opened by the elasticity of the bow, as the nut *a* is receded on the screw *b*, and are approached by the contrary motion of the nut. It is a small pair of compasses, and may be of similar construction to the larger; that is, the legs may be united by a rivet, dispensing with the bow. Some of them have shifting legs, so as to substitute pen, pencil, the ordinary point, or the needle-point. They then lack all the specialties of the bow-pen except size.

C (Fig. 847) shows a revolving bow pen and pencil, so called, although the bow is absent. The pen *c* and pencil *d* are at the respective ends of a leg which rotates on an axis *e* to bring either into position.

A is a *spring bow-pen.*

B a *spring bow-pencil.*

Bow-pen'cil. A form of compasses of the smaller kind which are capable of delicate adjustment for describing minute circles and arcs of small radius. The mode of adjustment is similar to the bow-pen. It is also tolerably evident from the figure. A black lead-pencil pared down to a small size, or the lead from a pencil, is clamped in the socket, and is advanced as it wears or is shaved away in sharpening. See BOW-PEN, *B.*

Bow-pin. (*Husbandry.*) A cotter or key for holding in place the bow of an ox-yoke.

Bow-saw. A saw having a thin blade, kept taut by a straining frame in the manner of a bow and string. A *sweep-saw* or *turning-saw.* See FRAME-SAW.

Bow'sprit. (*Nautical.*) A spar projecting forward from the bows of a vessel. It supports the jib-boom and flying jib-boom, and to it and these spars the fore-stay, fore topmast-stay, etc., are secured. It is tied down by the *bobstays* and by the *gammoning.* It is stayed laterally by the *bowsprit-shrouds.* It rests upon the *stem* and the *apron.*

The part which rests on the *stem* is the bed; the inner part from that point is the *housing;* the inner end is the *heel;* the outer end the *head* or bees-seating.

The *gammoning* is the lashing by which the bowsprit is secured to the *knee* of the *head.*

The *martingale* is a spar depending from the bowsprit-end, and is used for reeving the stays.

The *heel-chain* is for holding out the jib-boom, and the *crupper-chain* for lashing it down to the bowsprit.

The bowsprit has —

Heel.	*Bobstays.*
Head.	*Shrouds.*
Fiddle or *bees.*	*Martingale.*
Chock.	*Dolphin-striker.*
Gammoning.	

Bowsprits are *standing*, that is, permanent, as in large vessels or sloops; or *running-in* bowsprits, as in cutters.

Bow-string Bridge. One in which the horizontal thrust of the arch or trussed beam is resisted by means of a horizontal tie attached as nearly as possible to the chord-line of the arch.

Girders and beams have also been constructed in the same way. The arched-beam roof of the New York and Harlem Railway Depot, New York, illustrated opposite to page 139, is of this character.

The roadway forms a chord, and is supported by tension-rods from the arches which span the space between abutments.

The Howslett bridge, erected by Mr. Leather, has a span of 152 feet; versed sine, 33 feet; hight above water, 43 feet; width, 33 feet; cost, £4,200.

Fig. 848.

Bow-String Bridge at Howslett, England.

Bow-string Gird'er. A *bow-string girder* consists of an arched beam resisting thrust; a horizontal tie resisting tension and holding together the ends of the arched rib; a series of vertical suspending-bars by which the platform is hung from the arched rib; and a series of diagonal braces between the suspending bars. See previous article.

Bow'tel. (*Architecture.*) The shaft of a clustered pillar, or a shaft attached to the jambs of a door or window.

Bow'tell. (*Architecture.*) A plain circular molding.

Box. A receptacle in which something else is held or contained, frequently deriving its specific name from the article it is intended to contain; sometimes from its mechanical purpose or association, or its material.

Axle-box.	Pepper-box.
Ballot-box.	Plant-box.
Cartridge-box.	Post-office box.
Fare-box.	Railway-car axle-box.
Fruit-box.	Resistance-box.
Hat-box.	Signal-box.
Journal-box.	Stuffing-box.
Letter-box.	Thread-box.
Match-box.	Ticket-box.
Paper-box.	Wheel-hub box.

The more important of these will be considered under their alphabetical heads.

The boxes of ancient Egypt were made with great neatness, the lids being hinged in various ways and well fitted. In the Abbott Museum, New York City, and in other collections, are many specimens. For example: —

Carved mummy-cases built up of parts doweled together, or of single blocks, forming the case and lid respectively, hollowed out by the adze and scorper.

Boxes carved in the shape of cats, and hollowed out to receive mummies of those animals. The cases are painted and have glass eyes.

Boxes carved like scarabæi, and used to contain unguents. Others bored like reeds, to hold the *kohl* used to blacken the eyelids, as in the days of Jezebel.

The boxes have sliding or hinged lids in great variety, and some of them in excellent taste. They are made of wood, stone, bone, marble, porcelain, hippopotamus tooth, etc., and are inlaid, carved, painted, and decorated with ornaments.

2. (*Machinery.*) *a.* A journal-bearing. It usually consists of two brasses with semi-cylindrical grooves; one piece rests upon the journal, which lies in the other piece. See PILLOW-BLOCK; AXLE-BOX; CAR-AXLE.

b. A chamber in which a valve works.

c. See STUFFING-BOX.

3. (*Hydraulics.*) *a.* A pump-bucket. A hollow plunger with a lifting-valve.

b. The upper part of a pump-stock.

4. (*Locksmithing.*) The socket on a door-jamb which receives the bolt.

5. A drain with a rectangular section.

6. A square notch cut into a sugar-tree to start and catch the *sugar-water* (in the West) or the *sap* (in the Eastern States). It is considered more wasteful of the timber than tapping with the gouge or the auger.

7. (*Weaving.*) *a.* The pulley-case of a draw-loom on which rest the small rollers for conducting the tail-cords.

b. The receptacle for the shuttle at the end of the *shed*.

8. (*Printing.*) A compartment in a *case* appropriated to a certain letter.

9. (*Founding.*) A flask or frame for sand-molding.

10. (*Vehicle.*) *a.* The iron bushing of a nave or hub. See AXLE-BOX.

b. The driving-seat of a coach or close carriage.

11. (*Vise.*) The hollow screw-socket of a bench-vise.

Box and Tap. (*Machinery.*) A device for cutting wood screws for carpenters' benches, clamps, bedstead-rails.

Box-beam. (*Metal-working.*) A beam of iron plates secured by angle-iron, and having a double web forming a cell. See GIRDER.

Box-car. (*Railroad Engineering.*) A closed car intended for freight.

Box-drain. (*Hydraulic Engineering.*) An underground drain built of brick and stone, and of a rectangular section.

Box-frame. (*Carpentry.*) A casing behind the window-jamb for counterbalance-weights.

Box-gird'er. (*Building.*) An iron beam made of boiler-plate, the four sides riveted to angle-iron.

Box'ing. 1. (*Joinery.*) The casing of a window-frame into which inside shutters fold.

2. (*Shipwrighting.*) The scarf-joint uniting the stem with the keel.

3. (*Wood-working.*) The fitting of the shoulder of a tenon in the surface of the timber, which is mortised for the reception of the tenon.

4. A mode of cutting a deep and hollow notch into sugar or pine trees to catch the flow. The notch differs in the respective cases, but in each a piece is boxed out, and the process thus differs from the *boring* or *tapping* of the maple and from the *hacking* of the pine.

Box-i'ron. A hollow smoothing-iron, heated by a hot iron within.

Box-key. An upright key, used for turning the nuts of large bolts, or where the common spanner cannot be applied.

Box-lock. (*Locksmithing.*) A rim-lock fastened to the side of a door without mortising.

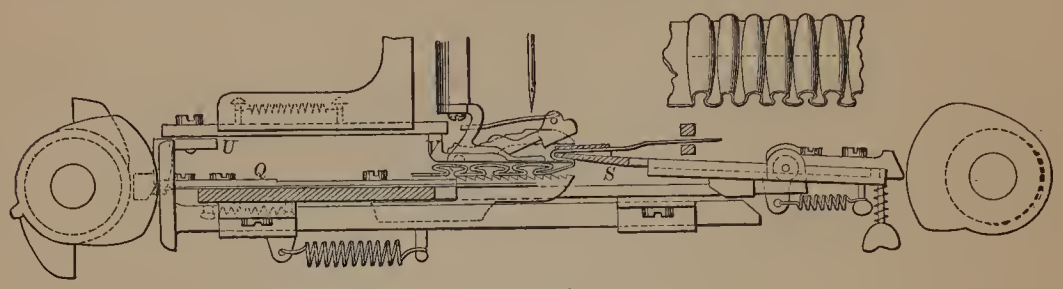
Box-mak'ing Machine'. One in which the bottom, side, and end pieces are set in place and their nails driven by advancing punches, which sink them into place.

Box-met'al. For bearings: copper, 32; tin, 5. Strubing's: zinc, 75; tin, 18; lead, 4.5; antimony, 2.5. See ALLOY.

Box-o'pen-er. (*Carpentry.*) A tool with a forked claw and a hammer-head, for tearing open boxes by lifting their lids, drawing nails, etc. Some combination tools have also a pincher and screw-driver.

Box-plait'ing. A device to fold cloth alternately in opposite directions, forming box-plaits on one side. Two plaiters *Q U*, one located directly above the other, reciprocate alternately in the direction of the feed-movement, and a third plaiter *S*, with a trough-like mouth, and containing the cloth to be laid in box-plaits, reciprocates also in the direction of the feed, and has also a rising and falling movement, so as to bend the cloth carried by it first over one plaiter and then under the other. Each time a

Fig. 849.

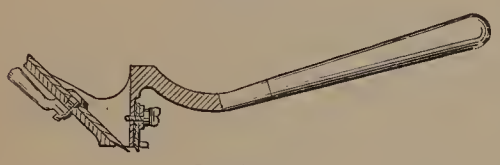


Box-Plaiting.

fold is so formed, it is caught and secured by the needle-thread, and the material is moved along by the feed for a new plait.

Box-scrap'er. (*Carpentry.*) A tool for erasing names from boxes. It is a mere scraper with an

Fig. 850.

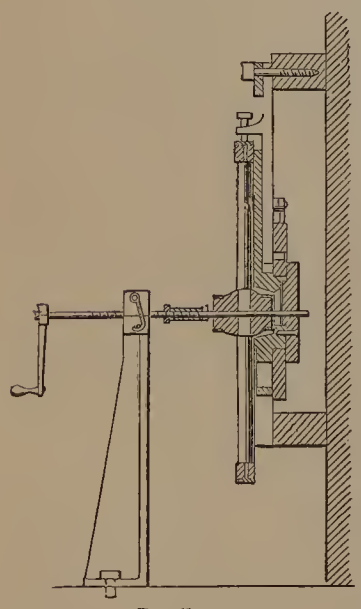


Box-Scraper.

edge presented obliquely, or, as in the example, works after the manner of a spoke-shave.

Box-set'ter. (*Wheelwrighting.*) A device for setting axle-boxes in hubs so as to be perfectly true. In the example the wheel is poised on its axis, and clamped by jaws above and below the hub. Its rim is held by grippers on radial bars which hold the wheel against stationary bearings in a plane perpendicular to the axis of the boring-spindle. The latter is mounted in the sockets, and carries cutters, which are fastened in a mortise in the spindle by means of a sleeve, screw-nut, and screw.

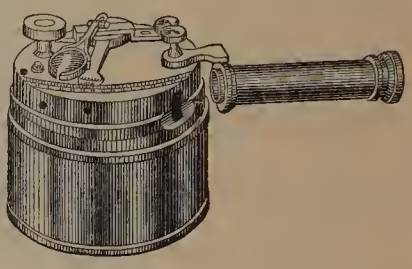
Fig. 851.



Box-Setter.

Box-Sex'tant. A small sextant inclosed in a circular frame. Used principally for triangulating in military reconnoisance, etc. It is on the principle of the ordinary sextant, having mirrors for bringing the reflected and direct images of an object into coincidence as a means of measuring their angular distance. See SEXTANT.

Fig. 852



Box-Sextant.

Box-slip. (*Plane.*) A slip of box inlaid in the beechwood of a tongueing, grooving, or molding plane, in order that the edge or the quirk may possess greater durability. The edges and quirks are rabbets or projections, which act as fences or gages for depth or distance.

Box-sta'ple. (*Carpentry.*) The *box* or *keeper* on a door-post, into which is *shot* the bolt of a lock.

Box-strap. (*Machinery.*) A flat bar, bent at the middle, to confine a square bolt or similar object.

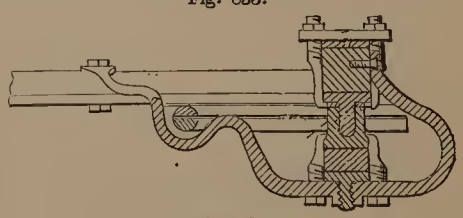
Box-turn'ing Ma-chine'. (*Turning.*) A lathe specifically adapted for turning wooden boxes and lids, for matches, spices, or other matters. Such lathes have convenient chucks, rests for the side-turning and for the bottoming tool which gives the flat bottom.

Boy'au. (*Fort.*) A trench of zigzag form, to avoid an enfilading fire, leading from one parallel of attack to another, or to a magazine or other point.

Brace. 1. (*Carpentry.*) A diagonal stay or scantling, connecting the horizontal and vertical members of a truss or frame, to maintain them at a prescribed angular relation.

2. (*Printing.*) *a.* A printer's sign; a crooked line connecting several words or lines; *vide*, ⁓.

Fig. 853.

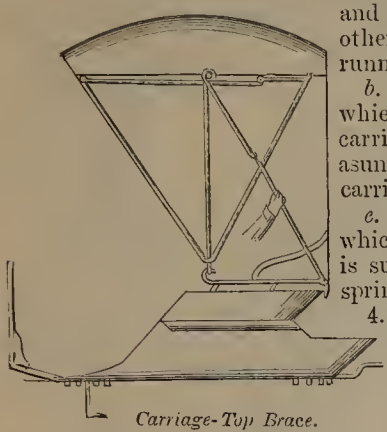


Carriage-Brace.

b. The stays of a printing-press, which serve to keep it steady in its position.

3. (*Vehicle.*) *a*. An iron strap passing from the head-block, behind and below the axle, and forward to another portion of the running-gear.

Fig. 854.



Carriage-Top Brace.

b. A jointed bar by which the bows of a carriage-top are kept asunder, to distend the carriage-top cover.

c. A thick strap by which a carriage-body is suspended from C-springs.

4. (*Boring-Tools.*) *a*. (*Wood-working.*) A revolving tool-holder, one end of which is a swiveled head or shield, which rests in the hand or against the chest of the operator; at the other end is a socket to hold the tool. Called also a *stock*, more particularly in metal-working.

The varieties of the instrument principally hinge upon the mode of attaching the bit.

Varieties depending upon other differences are: —

Angle-brace; a corner drill.

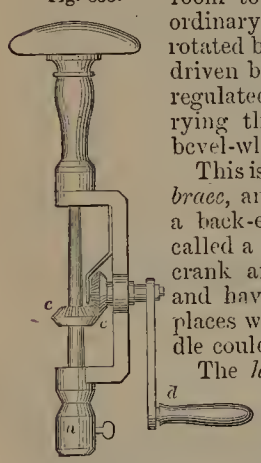
Crank-brace; the usual form.

Hand-brace; with a swiveled breast-plate.

Lever-brace; worked with an oscillating lever, usually having a ratchet motion. See RATCHET-DRILL.

b. (*Machinery.*) The *angle-brace* is used in places, such as angles, where there is not room to revolve the handle of the ordinary brace. The drill-stock *a* is rotated by means of bevel-pinions *c c*, driven by a crank *d*. Speed may be regulated by changeable gearing, varying the relative sizes of the two bevel-wheels.

Fig. 855.

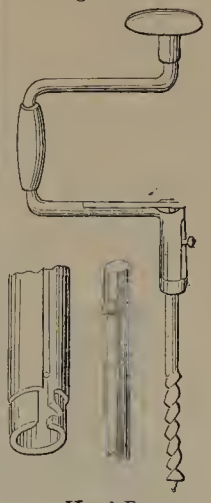


Angle-Brace.

This is sometimes called the *French brace*, and when made of metal with a back-center and feed-screw, it is called a *corner-drill*, being driven by crank and bevel-gearing as before, and having a capacity for reaching places where the ordinary brace-handle could not be revolved.

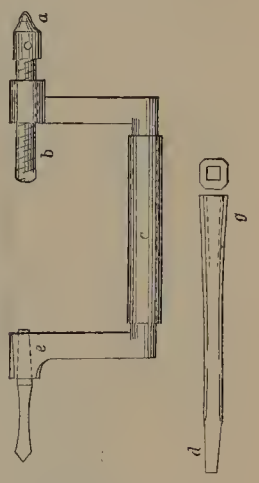
The *hand-brace* (Fig. 856), otherwise the *crank-brace*, has a socket for the bit, a crank for revolving it, and a swiveled head for the pressure of the hand or the breast of the workman.

Fig. 856.



Hand-Brace.

Fig. 857.



Machinist's Brace.

The machinist's brace depends upon a rigid bearing for the back-center *a* and a feed-screw *b* for keeping it to its work, the requirements being far beyond the pressure that can be given to a swiveled head by the breast of the workman. A sleeve *c* upon the handle rotates on the stock as the tool revolves.

An extension-shank is used as a temporary addition to the length of the tool, to enable the latter to reach deep-seated parts. The tang *d* fits into the socket *e* of the brace, and the tang of the drill into the socket *g* of the extension-piece.

5. (*Nautical.*) A rope passing from the end of the yard to another mast, and serving to trim the yards fore and aft.

6. (*Shipwrighting.*) One of the eye-bolts on which the hooks of the rudder are secured. The *gudgeons* or *goggings*.

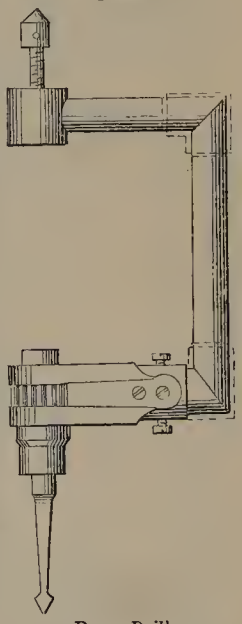
7. (*Music.*) One of the cords of a drum by which the heads are stretched.

8. (*Mining.*) The mouth of a shaft.

9. A stay for a trunk-lid or similar duty.

Brace-drill. (*Metal-working.*) A boring-tool shaped like a brace, having a tool rotated by the revolution of the handle. In the example, the motion may be continuous or reciprocating rotary, the swinging portion being connected to the cutter-stock by a pawl on the former and ratchet on the latter.

Fig. 858.



Brace-Drill.

The ratchet-head of the brace is attachable to a lever to form a swing-brace or a rotary brace-frame.

Brace-pen'dant. (*Nautical.*) A short pendant from the yard-arms, to hold the brace-block.

Brac'ing-chain. (*Vehicle.*) The chain which ties together the sides of a wagon, to prevent the load from breaking them apart. Used especially in wood and freight wagons.

Brack'et. A lateral projection from a wall, post, or standard, to strengthen or support another object; to strengthen an angle; to support a heavy cornice or an entablature.

Of the parts of a bracket, —

a is the *sole*.

b the *wall-plate*.

c the *rib*.

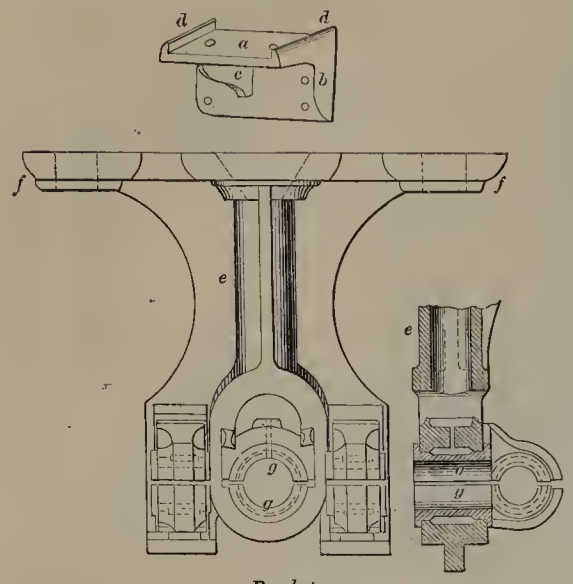
d a *snug* or *flange*. See Fig. 859.

This description of support is also adapted for shelves, coves, soffits, and seats.

1. (*Machinery.*) The *shafting-bracket* (Fig. 859) is a hanger which contains the journal for shafting. *c* is the pedestal, supported by the extended arms *f f*, which are bolted to the joists of the ceiling. *g g* are the parts of the boxing which are in immediate contact with the shaft.

Brackets for shafting are known by different names, according to structure and position.

Fig. 859.



Brackets.

Pendent brackets or *hangers*, when the shafting is suspended from the ceiling.

Wall-brackets, when fixed against a perpendicular wall.

Wall-boxes, when the shaft passes through a wall or partition furnished with a bearing.

Pedestal-brackets, when the support rises from a foundation or bed-plate.

Fig. 860.

2. (*Architecture.*) *a.* An ornament in the shape of a console, standing isolated upon the face of a wall.

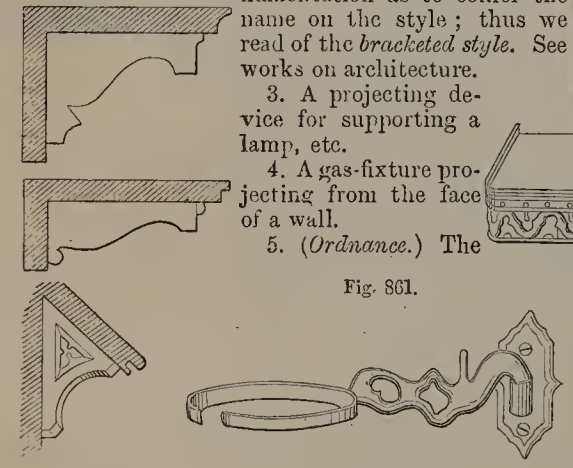
b. Roof-brackets are placed beneath the eave or the projection at the gable, and have shapes conforming to the style of the architecture or the necessities of their position. In some cases the bracket is so prominent a feature in the ornamentation as to confer the name on the style; thus we read of the *bracketed style*. See works on architecture.

3. A projecting device for supporting a lamp, etc.

4. A gas-fixture projecting from the face of a wall.

5. (*Ordnance.*) The

Fig. 861.



Roof-Brackets. *Lamp-Bracket.*

cheek of a mortar-bed, or the carriage of a ship's or casemate gun.

6. (*Shipbuilding.*) A timber-knee in a ship's frame, supporting the gratings.

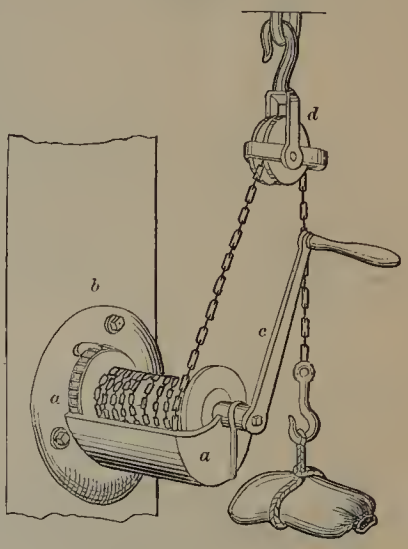
7. (*Steam-Engine.*) *a.* The pieces by which the boiler of a locomotive is maintained in position.

b. The pieces which hold and guide the slide-bars.

8. (*Printing.*) Signs ("[ ]") used to inclose a word or sentence, to isolate it from the other matter. The *bracketed* portion may be a note, protest, explanation, authority, reference, comment, rectification, interpolation, query, emphasis, etc.

Brack'et-crab. A hoisting apparatus, designed for attachment to a post, wall, etc.

Fig. 862.

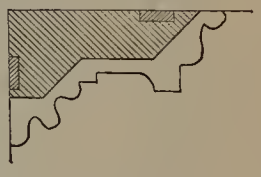


Bracket-Crab.

In the drawing the chain-drum is shown journaled in a frame *a*, attached by bolts to the post *b*, and is turned by the handle *c*. The tackle is shown as a single whip, the chain being rove through the single-sheave block *d*.

Brack'eting. A skeleton support for moldings. This plan is commonly adopted in making the arches, domes, sunk panels, coves, pendentive work, etc., at the upper parts of apartments. The brackets are got out, of the required contour, nailed into position, and form a basis for the reception of the lath and plastering.

Fig. 863.



Bracketing.

In domed work, *spherical bracketing* is the forming of brackets to support lath and plaster work, so that the surface of the plaster shall form the surface of a sphere.

Spheroidal bracketing is the bracketing prepared for a plaster ceiling whose surface is to form that of a spheroid.

Brack'et-shelf. A form of console for supporting a pier-glass or other object.

Fig. 864.

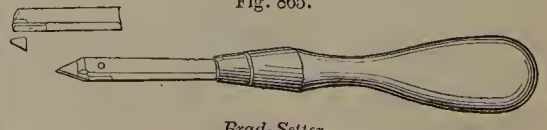
Bracket Shelf and Drawer.

Brad. A thin, square-bodied nail, whose head has a lip on one side only. See NAIL.

Brad'awl. (*Joinery.*) A small boring-tool with a chisel-edge. Used for opening holes for the insertion of nails.

Brad-set'ter. (*Joinery.*) A tool which grasps

Fig. 865.



Brad-Setter.

a brad by the head, and by which it is driven into its appointed place.

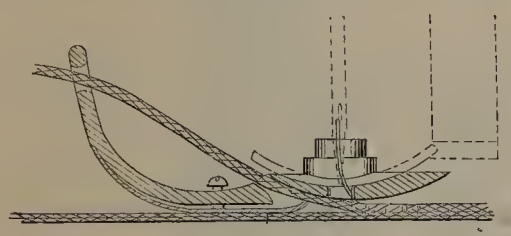
Braid. (*Fabric.*) A narrow woolen woven goods, used for binding.

Among the materials used for bonnet-braid may be mentioned, —

Bass or linden bark.	Worsted thread.
Cotton thread.	Linen thread.
Flax thread.	Straw.
Hemp.	Chip.
Horse-hair.	Paper strips.
Palm-leaf.	Wood splints.
Wool thread.	Majuaja.

Braid'er. A sewing-machine attachment provided with an opening to guide and lay a braid on the cloth under the action of the needle. The braid-guiding opening may be in the presser and in advance of the needle-hole, or in the cloth-plate, or in a separate attachment secured to the cloth-plate.

Fig. 866.

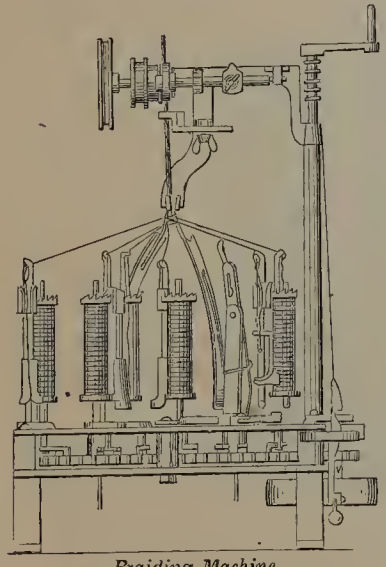


Braider.

See "Sewing-Machine Attachments," G. W. Gregory, Washington, D. C. In the example, the guide is attachable to the presser-foot of a sewing-machine; the object is the increased facility for guiding the braid, especially in laying it in curved directions on the cloth; also the concave form of the groove, in connection with the pressure of the spring on the braid, tending to keep the braid within the groove, and prevent its passing to one side thereof.

Braid'ing-ma-chine'. A machine in which a fabric is made by the laying up of three or more threads by a plaiting process. Mechanism guides the thread-holding bobbins in a serpentine course, to interlace the threads. Threads, from three to thirty, are twisted one around another by revolving wheels, spindles, etc., making braid, stay, and shoe laces, upholsterer's cord, and coach-lace. It is also employed for covering whips, threads of caoutchouc, the wires of crinoline, etc.

Fig. 867.



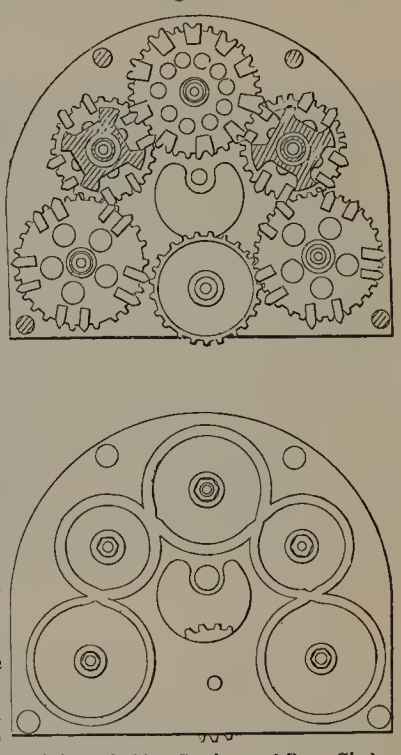
Braiding-Machine.

Braiding-machines are made of all sizes, from machines braiding seven strands to those braiding eighty-five, this being the limit at present of flat braids manufactured in the United States; though round braiders, or machines for covering tubes, are built capable of braiding ninety-six strands. The sizes of round braiders most largely in use, however, are those braiding sixteen and twenty strands, which are the sizes used in the manufacture of shoe-strings and covering hoop-skirt wires. The sizes of flat braiders most in use are those braiding fifty-three and sixty-five strands worsted yarn, which produce the common dress braids now so commonly worn. The production of American machines is about a million yards daily of dress braids.

The braid is passed through fire to relieve it of its floss, and prepare it for the dyer.

The views (Fig. 868) are respectively elevation and plan of a braiding-machine. The elevation shows the mode in which the spindles and bobbins are arranged relatively to the skirt-wire, around which the strands are being plaited. The lower figure shows a view of the carriers, and of the race-circles, in which the spindles are caused to move, so that they move in and out, crossing each other's paths, and thus interlace the strands. When the braid is to be laid up tubular, as in covering upholsterer's cord, whips, and skirt-wire, the set of race-circles form a continuous series around, and the spindles make the complete circuit, again and again repeating the serpentine course in the same direction. The upper figure represents a machine of this kind. When the braid is to be laid up flat, as in the drag and other common braids, each *racer*, as the spindle-holders are called, makes a single course, turns round the last race-circle of the series, and then returns, intersecting its own former path as it follows the circles shown in the lower part of the figure. The upper part shows the carriers which impel the racers, each one delivering the racer to the next carrier in series, which it impels along its allotted path in the circle. The two figures represent the carriers and race-circles of a machine for laying up flat braid. By a still farther refinement of the process, the machine is adapted for making two or more distinct braids connected at their edges; thus admitting of different-colored stripes. Each racer for this purpose goes only through its own course of race-circles, one of which circles is common to the two carriers.

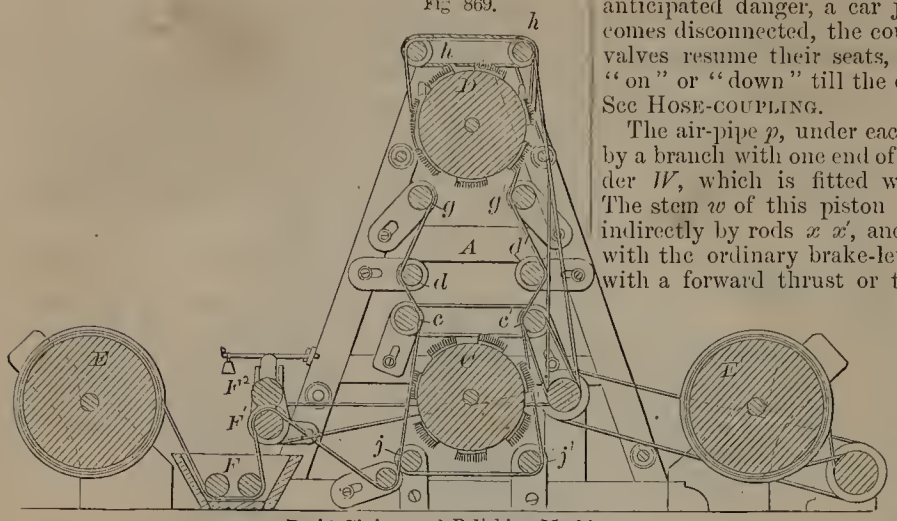
Fig. 868.



Braiding-Machine Carriers and Race-Circles.

Braid Siz'ing and Pol'ish-ing. The braid is passed from a reel E through a sizing-trough F, to pressure-rollers F' F^2, and then over guide and tension rollers j c d g h h' g' d' c' j', which hold it obliquely against the brushes on drums C D. It is then drawn off by a reel E', which receives intermittent motion

Fig. 869.



Braid Sizing and Polishing Machine.

from a toothed wheel actuated by projections on the end of the lower brush-shaft engaging with the teeth.

Brails. (*Nautical.*) Ropes used to gather up the foot and leeches of a sail, preparatory to furling.

The *brails* of a *gaff-sail* are for hauling the after-leech of the sail forward and upward, previous to furling: towards the *head* (*peak-brails*); *neck* (*throat-brails*); and *luff* (*foot-brails*). The *lee-brails* are hauled upon in furling.

Brake. 1. (*Railroad Engineering.*) A contrivance for stopping the motion of a car-wheel by friction applied thereto.

Car-brakes, until the advent of the atmospheric brake, were actuated by a winding drum, connecting chains and levers, the power of the brakeman being applied to a hand-wheel on the car platform. The principal modes of application of the hand-operated brake are explained under CAR-BRAKE (which see). In the same article are detailed a number of devices for the use of air, steam, the colliding of the cars, friction, fect on the track, etc., for arresting the motion of the cars.

The Westinghouse Atmospheric Brake, illustrated by the folding plate opposite, was patented in 1869, and has been adopted on many railway lines in the United States and in Europe. Its chief features are, first, the use of compressed atmospheric air as a means of applying the brakes; and, second, putting the whole braking-apparatus under the direct control of the locomotive engineer, so that he can apply the brakes at pleasure, instantaneously, or gradually, and with any desired power, limited only by the power of the air-compressing apparatus and the strength of the air-vessels. The construction of the apparatus is shown by elevation and section. A small but powerful direct-acting steam-engine *A* is secured to the frame of the locomotive above and between the driving-wheels. This engine operates the air-pump *B*, and thereby the air is compressed to any desired density into a receiver or reservoir *Y*, which is arranged under the cab. Each car is provided with a line of air-pipes *p p*, which are united between the cars by flexible hose *r r*, and suitable couplings. Each half-coupling contains a valve so constructed that, when the hose are coupled up, the valves are automatically unseated, so as to make an open continuous air-pipe through the train, and, when uncoupled, each valve will automatically resume its seat. Hence, the valve of the rear coupling of the rear car of a train will always be closed, and if, after the brakes are applied in view of actual or anticipated danger, a car jumps the track and becomes disconnected, the couplings will separate, the valves resume their seats, and the brakes be held "on" or "down" till the car comes to a full stop. See HOSE-COUPLING.

The air-pipe *p*, under each car, makes connection by a branch with one end of a cast-metal brake-cylinder *W*, which is fitted with an ordinary piston. The stem *w* of this piston is connected directly (or indirectly by rods *x x'*, and "progressive lever" *X*) with the ordinary brake-levers in such a way that, with a forward thrust or throw of the piston, the brake-shoes will be applied to the car-wheels, and by a reverse movement they will be released or "let off." A three-way cock *M* in the air-pipe, just outside the reservoir *Y*, is within reach of the locomotive engineer. In ordinary running all communication between the reservoir *Y* and the air-pipes *p* is closed. The engineer, at pleasure, turns the cock *M*, so as to open this communication, and permit the compressed air to flow back into the brake-cylinders *W*, either partially if he merely wishes to check the speed of his train on a down grade, or more completely for an ordinary stop, or instantaneously and fully in anticipation of immediate danger. By another adjustment of the cock, he closes the communication again, and opens a port for the escape of the compressed air from the brake-cylinders. The brakes are then "off," and the wheels free.

The construction is such as not to interfere with the ordinary operation of the brakes by hand. For ordinary passenger-trains, an air-pressure is commonly required of from 30 to 60 pounds per square inch. The capability of this brake is best shown by the following report of tests made.

At a test on the Kansas Pacific Railway, May 12, 1871, a train going at the rate of 45 miles an hour was stopped within a distance of 250 feet.

On September 18, 1869, a test was made on the Pennsylvania Railroad, at the famous "Horseshoe Bend." The train of six cars, running down a grade of 96 feet to the mile, at the rate of 30 miles an hour, was brought to a stand-still in 420 feet,—seven car-lengths.

The steam-ejector has also been employed by Mr. Westinghouse, under a patent granted to him in 1871, for exhausting the air from the brake-cylinders in front of the pistons, and thus applying the brakes by a "vacuum" or atmospheric pressure. See GIFFARD INJECTOR.

2. (*Machinery.*) A friction strap or band applied on the periphery of the drum of a hoisting-machine, crane, or crab.

Or it may consist of a pivoted lever, having a shoe at one end, and a rope attached to the other, by pulling which the shoe is pressed against the rim of the wheel.

Of this class is the rim of wood surrounding the inclined wheel attached to the sail-shaft of a windmill, and pressed down thereon by a lever to stop the mill.

3. (*Vehicle.*) *a.* A vehicle for breaking horses, consisting of the running-gears, and a driver's seat, without any carriage-body.

b. A rubber pressed against the wheel of a vehicle, to impede its revolution, and so arrest the descent of the vehicle when going down hill.

The old Herodes Atticus, the rhetorician, refers to

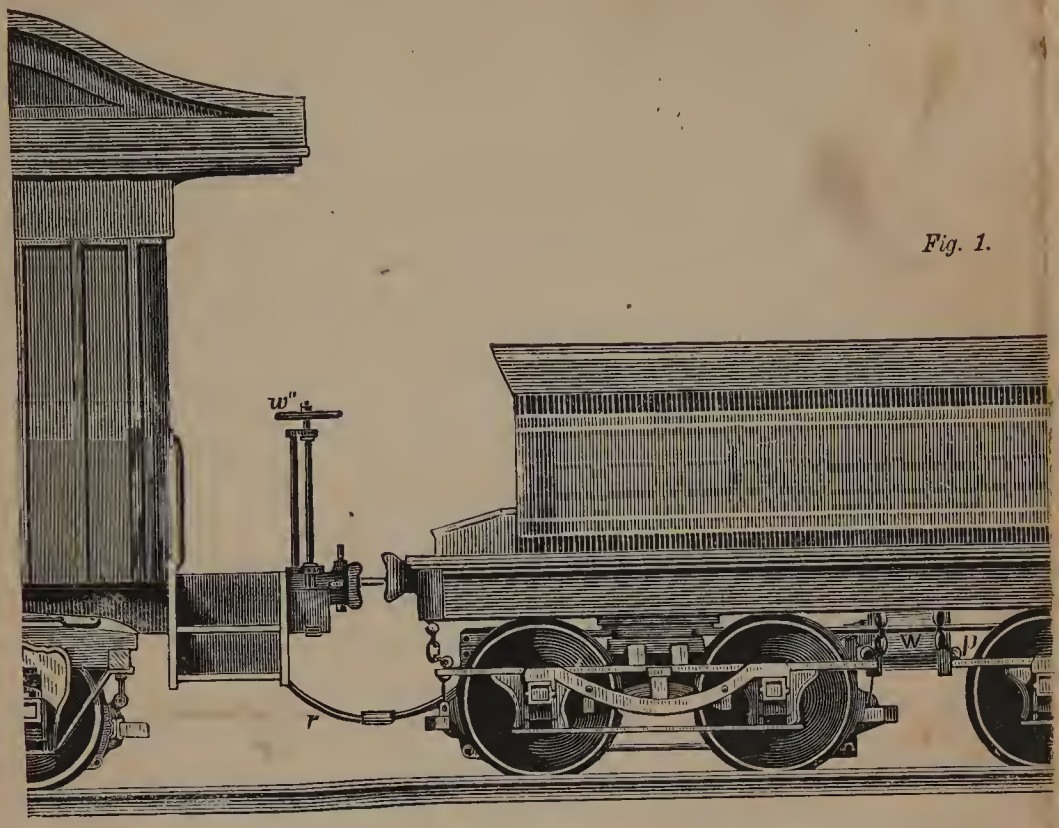
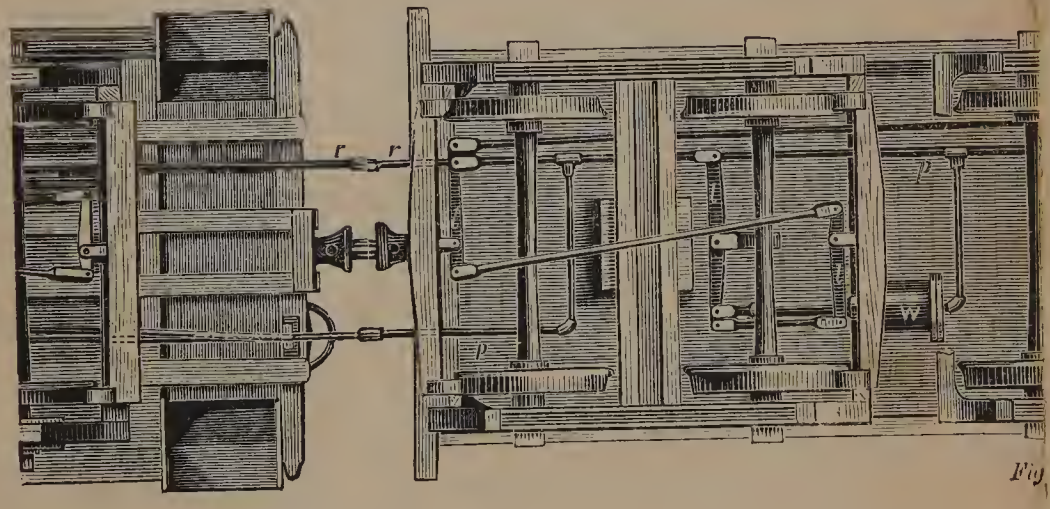


Fig. 1.



Fig

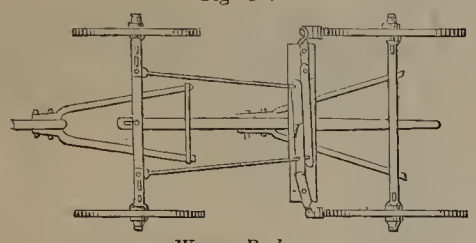
PLATE VII.

the *fetter to the wheels*, used when his chariot was descending a hill. It appears to have been only a stick put through the wheels.

The example shows it as applied to a vehicle.

The fore-axle is so connected to the compound brake-levers that backward pressure in descending a

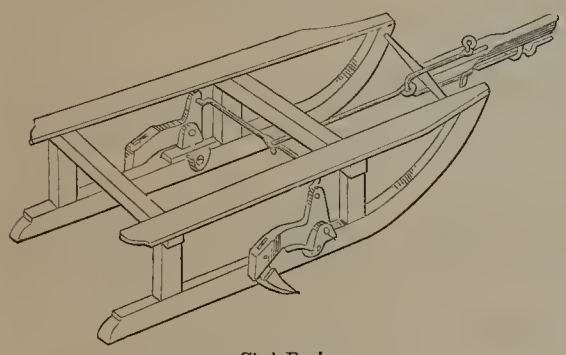
Fig 870.



Wagon-Brake.

hill will put the brakes into action. This movement of the axle is prevented, when backing the wagon, by the pendent part of an oscillating lever upon the

Fig. 871.



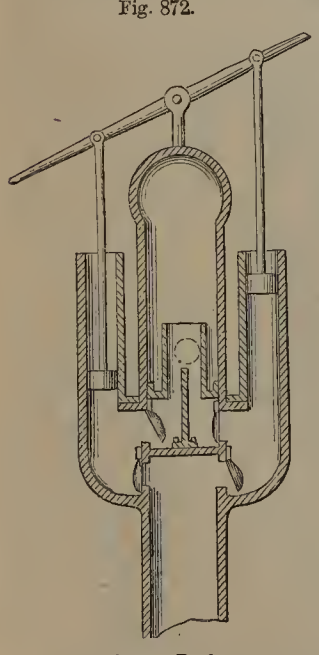
Sled-Brake.

box, which is brought in contact with the axle. See WAGON-BRAKE.

c. The part of a carriage by which it is enabled to be turned. The fore-carriage.

Brakes for sleds and sleighs consist of spurs brought into action by scraping on the ground. In the example, the brake-dogs are pivoted in a wedge-shaped mortise in one arm of a bell-crank, to whose other arm is connected a bar sliding beneath the tongue and operating by holding back on the tongue.

Fig. 872.



Pump-Brake.

4. (*Husbandry.*) *a*. A machine for separating the bark and pith from the fiber of hemp or flax; to loosen the *boon* and *shives* from the *hare*. See FLAX-BRAKE; HEMP-BRAKE.

b. An English term for a heavy harrow.

5. (*Farriery.*) *a*. A frame for confining refractory animals while being shod or undergoing operations.

b. A sharp and heavy snaffle for breaking or subduing untrained or vicious horses.

6. A name for the BALLISTA (which see).

7. (*Hydraulics.*) The extended handle of a fire-engine or similar pump, by which the power is applied. Said especially of an extended handle at which a row of men can work together.

8. (*Basket-making.*) An iron crotch with a sharp-edged reëntering angle, adapted to peel the bark from osiers drawn therethrough.

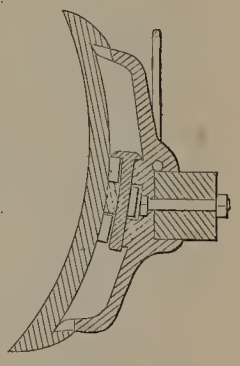
9. The baker's kneading-machine; consisting, in some cases, of a pivoted lever operating on a bench; the name now including other machinery for effecting the same purpose.

Brake-beam. (*Vehicle.*) The transverse beam connecting the shoes of opposite wheels. A *brake-bar*.

Brake-block. (*Railroad Engineering.*) The block attached to the brake-beam and holding the *shoe* or *rubber*.

Brake-shoe. That part of a brake which is brought in contact with the object whose motion is to be restrained.

Fig. 873.



Brake-Shoe.

Brake-sieve. (*Mining.*) A rectangular sieve operated by a forked lever or *brake*, from which it is suspended in a cistern of water for the agitation of comminuted ore. The meshes are of strong iron wire, $\frac{3}{8}$ of an inch square. The brake is supported by a rolling axis. See JIGGER. The poorest light pieces are *cuttings*. Pieces of poor, sparry, heavy ore are *chats*.

Brake-wheel. 1. (*Railroad Engineering.*) The wheel on the platform or top of a car by which the brakes are operated.

2. (*Machinery.*) A wheel having cams or wipers to raise the tail of a hammer-helve.

Brak'ing. (*Flax-manufacture.*) An operation by which the straw of flax or hemp, previously *steeped* and *grassed*, is broken, so as to detach the *shives* or woody portion from the *hare* or useful fiber. See FLAX-BRAKE.

Brak'ing-ma-chine'. A machine for *braking* flax or hemp after rotting, to remove the woody portion and pith from the fiber. See FLAX-BRAKE.

Bra'mah-lock. A lock patented by Bramah, in England (1784 and 1798), having a number of slides which are adjusted in the manner of tumblers, by means of a stepped key, so that the slides of unequal length shall be brought into a position where their notches lie in the same plane, that of the locking-plate. See LOCK.

Bra'mah-press. The HYDROSTATIC PRESS (which see).

Branch. 1. (*Fortification.*) *a*. The *wing*, or long side of a horn or crown work.

b. One of the parts of a zigzag approach.

2. (*Blacksmithing.*) One of the *quarters* or *sides* of a horseshoe.

3. (*Harness.*) One of the levers attached to the ends of the stiff bit of a curb-bit, and having rings or loops for the curb-chain, the cheek-straps, and the reins. See CURB-BIT.

4. (*Mining.*) A small vein which separates from the lode, sometimes reuniting. A *leader*, *string*, or *rib* of ore running in a lode.

5. (*Hydraulics.*) The metallic piece on the end of a hose to which the nozzle is screwed.

6. (*Gas-fixtures.*) A gas-burner bracket.

Branch-chuck. (*Turning.*) A chuck having

four branches, each of which has a set screw whose end may be made to impinge upon the object.

Brand. Paintings in the Theban tombs represent the branding of cattle on the shoulders with a hot iron, probably engraved with the owner's name.

Fig. 874.

Branding Cattle in Ancient Egypt (Thebes).

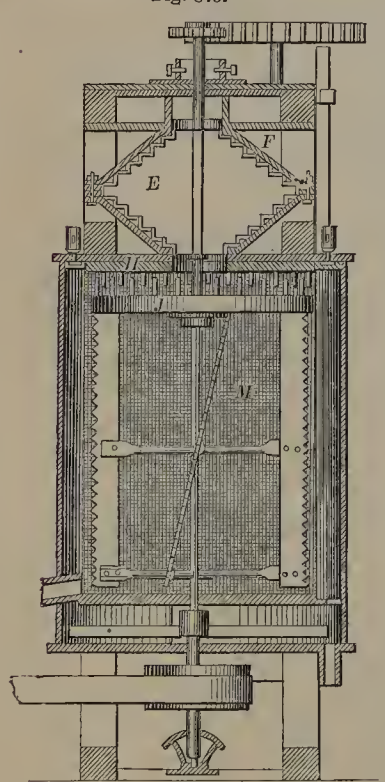
The cattle are represented lying on the ground with the feet tied. One person heats the iron in a portable furnace, and the other applies it to the shoulder of the animal.

Branding-tools for marking stock or boxes are of three kinds. One is adapted for being heated to burn away the hair or the wood, as the case may be. Another is used as a stencil, consisting of a plate with openings representing letters or device. The other consists of type in some form, generally set up in a small galley with a handle, so as to be conveniently manipulated. Novel devices are more generally in the latter line, and ingenuity is exercised in the modes of adjusting and securing the type in the holder. The faces of the types are made elastic in MASON'S patent. Skeleton-letters, secured by tangs to handles, are also used for this purpose, and may be readily dipped in a pigment, and applied to sheep or other stock.

Brand'rith. A fence or rail round the opening of a well.

Bran-dust'er. (*Milling.*) A machine in which the bran, as turned out of an ordinary bolt, is rubbed and fanned to remove as much as possible of the flour which yet adheres to it. In the example the bran passes between the radially ridged surface of the double frustum *F* and an enveloping jacket of similar form and surface. It then passes between the pin-armed head *H* of the cylinder and the head-disk *I* of a revolving frame, which carries inclined serrated plates which work the bran against the wire screen *M*. Cams of the spur-wheel above operate to agitate the screen to keep the meshes clear. The bran is finally discharged through one spout, and the other products through another.

Fig. 875.

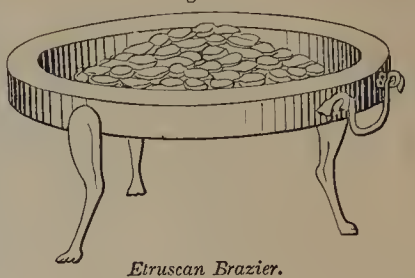


Bran-Duster.

Bran'ning. (*Dyeing.*) Preparing cloth for dyeing by steeping in a vat of sour bran-water.

Bra'sier. An open pan for burning wood or coal. The brazier (*foculus*) of the Romans was an elegant bronze tripod, supported by satyrs and sphinxes, with a round dish above for the fire and a small vase below to hold perfumes. It occupied the *atrium*, and represented the abode of hospitality and sanctuary, even after cooking had been banished to other apartments. A kind of close stove was also used; but, in either case, the smoke was so considerable that, as luxury advanced, the winter rooms were differently furnished from those appropriated to summer use. In order to prevent the wood from smoking, the bark was peeled off, and the wood kept long in water, and then dried and anointed with oil.

Fig 876.



Etruscan Brazier.

The Greeks and other nations commonly used it, and sought to correct the deleterious nature of the fumes by burning costly odorous gums, spices, and woods.

The Japanese warming-apparatus is a chafing-dish with a handful of charcoal let into the floor, like the Spanish *brasero*. This is very ineffective in mitigating the rigor of the season in the more northerly part of the main island, and the people depend principally on clothes, heaping gown upon gown.

Brass. 1. (*Alloy.*) An alloy of copper and zinc. It is fabled to have been first accidentally formed at the burning of Corinth by Lucius Mummius, 146 B. C.; but articles of brass have been discovered in the Egyptian tombs, which prove it to have had a much greater antiquity.

Brass was known to the ancients as a more valuable kind of copper. The yellow color was considered a natural quality, and was not supposed to indicate an alloy.

Certain mines were much valued, as they yielded this *gold-colored copper*, but after a time it was found that by melting copper with a certain earth (calamine), the copper was changed in color. The nature of the change was still unsuspected.

Tubal Cain's operations in iron and brass may be held to be iron and copper (Gen. iv. 22). The translation of terms referring to metals is not perhaps very accurate. Job is made to refer to brass several times, — copper most likely.

Hiram is said to have made articles of "brass" for the Temple of Solomon, 1004 B. C. This was probably bronze, which is made by the union of copper and tin, while brass consists of copper and zinc. Hiram procured his tin in Cornwall, England. Herodotus called Britain the Cassiterides, or Tin Islands, 450 B. C. Calamine was known in early times, and the Temple utensils may have been really brass.

The "brazen" bull was cast by Perillus of Athens, for Phalaris of Agrigentum, 570 B. C. It was made hollow, to receive victims to be roasted to death. The throat was contrived to make their groans simulate the bellowing of the animal. The artist was made to furnish the first victim, and the king eventually tried the experiment in person, 549 B. C.

The helmet of Psammitichus the Powerful was of brass, and from it he poured the libation in the Tem-

ple of Vulcan, which condemned him to temporary isolation in the marshes of the Delta, but ended in his making the acquaintance of some Ionian and Carian freebooters, who assisted in placing him on the throne of Egypt, 650 B. C.

Brass was known to the Greeks as *orichalcum* or mountain-bronze. Afterwards corrupted by the Romans into *aurichalcum*, from a supposition, derived from its color, that it had gold in its composition.

Brasses (*Composition of*).

	Brass.	Copper.	Zinc.	Tin.	Nickel.	Lead.	Glass.	Silver.
German brass (common)		1	1					
Good yellow brass		2	1					
Brass wire		2	1					
Muntz's sheathing-metal		3	2					
Red brass, to be soldered		8	3					
Common brass		3	1					
Pinchbeck		4	1					
Revere's sheathing-metal (1830)		95	5					
Collins's red alloy for sheathing		8	1					
Collins's yellow alloy for sheathing		10	8					
Collins's white alloy for sheathing		1	16	16				
Tough brass for engine work		20	3	3				
Brass for heavy bearings		32	1	5				
Pinchbeck		4	1					
Pinchbeck		5	2					
Tombac (*Malay*, *tambaga*, *copper*)		16	1	1				
Red tombac		88.8	11.2					
Red tombac		11	1					
Rolled brass		74.3	22.3	3.4				
Tutenag		50	31		19			
Brass gilding-metal (bronze color)		16	1–1¼					
Emerson's patent brass (English)		16	8					
Keller's statuary brass (Versailles)		91.40	5.53	1.70		1.37		
Chantrey's hard alloy		32	5	5				
Manheim gold		4	1					
Manheim gold		3	1	¼				
Semilor		5	1					
Mosaic gold (Hamilton and Parker's patent)		32	33					
Mock platinum	8		5					
Bath metal	32		9					
White brass		10	80	10				
Ormolu		48	52					
Speculum metal (Martin's patent, August 23, 1859)		100	133				5/8	16
Mushet's sheathing-metal (1823)		100	⅛					

The proportions are varied, and tin and antimony are added in some of the formulæ.

See also brasses and bronzes, with the addition of iron, p. 61, *ante*.

2. (*Machinery.*) In a mechanical sense a *brass* is a *pillow*, *bearing*, *collar*, *box*, or *bush*, supporting a gudgeon; so called from its being composed of either copper and tin or copper and zinc.

Brass-foil. Very thin beaten sheet-brass, thinner than *latten*. *Dutch-gold*.

Brass-fur'nace. Brass, or its component metals, is melted in crucibles; in the latter case, the copper being first melted, and the zinc then added piecemeal, as it is vaporized by an excess of heat.

The molding-trough *b* is on one side of the pouring or *spill-trough c*, and the furnace *a* is on the other. *d* is a core-oven, heated by the furnace, and serving to dry the cores for the faucets or other hollow articles which are cast.

The brass-furnace is usually built within a cast-iron cylinder, 20 to 24 inches in diameter, and 30 to 40 inches high, which is erected over an ash-pit, which is supplied with air through a diving-flue, which commences at a grating even with the floor of the foundry. The mouth of the furnace stands about 8 or 10 inches above the floor, and the upper aperture is closed with a plate, which is yet called the *tile*, though it is now usually of iron. A *tile* originally performed the duty. The inside of the furnace is contracted to about 10 inches by fire-bricks set in refractory clay, except a small aperture at the back, 4 or 5 inches square, which leads to the chimney.

A number of such furnaces usually stand in a row, and each communicates by its own flue with the tall stack, which carries off the volatile results of combustion, and the fumes of the zinc. Each furnace has a damper.

As a furnace burns out, so as to leave an excess of space between the crucible and the wall, the inside is renewed by plastering on a coating of road-drift and water, applied like mortar. This makes a surface, which is glazed by the fire-heat.

The workman is shown handling the *crucible-tongs*, the *reins* of which are closed by the *coupler*, while he pours the metal in at the *gate* of the *flask*, which rests in an inclined position against the *spill-trough*.

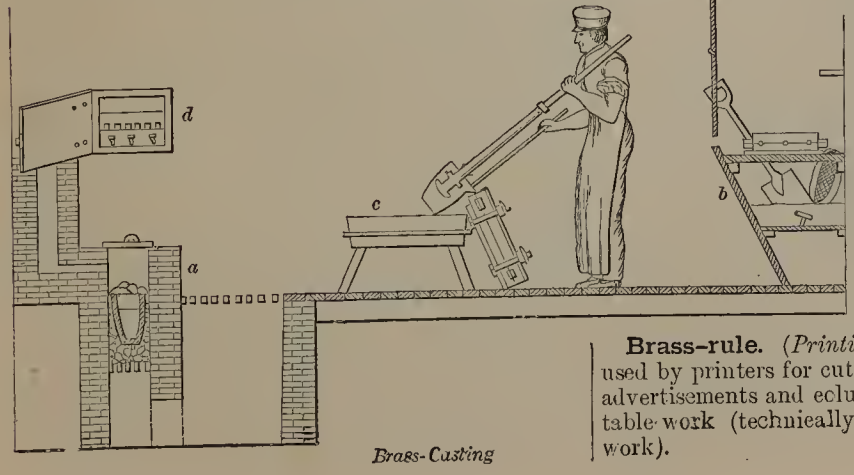
For large quantities of metal, for statues, bells, large guns, etc., the brass or bronze is melted in reverberatory furnaces.

Brass'ing. (*Metallurgy.*) Giving a brass coat to copper. It may be done by —

Exposing the copper in a heated state to the fumes given off by zinc at a high temperature;

Filling a copper vessel with water soured by hydrochloric acid, and adding an amalgam of zinc and cream of tartar, and boiling the whole for a short time.

Fig 877.



Brass-Casting

Brass-pow'der. (*Red-Colored.*) Grind copper filings or precipitated powder of copper with red ochre.

(*Gold-Colored.*) Gold-colored brass or Dutch leaf reduced to powder.

Mixed with pale varnish, or applied by dusting over a surface previously covered with varnish.

Brass-rule. (*Printing.*) Brass strips, type-high, used by printers for cutting into lengths to separate advertisements and columns; also for page-rules and table-work (technically known as *rule and figure* work).

They may have a single sharp edge or may be grooved to produce parallel lines.

Brat'tice. (*Mining.*) A planking on the inside of a mine shaft or gallery.

Notably, a plank-work partition in a shaft, dividing it into two portions.

Bray. (*Fortification.*) A tower or blockhouse in the outworks before the port.

Bray'er. (*Printing.*) A wooden muller used on the ink-table to temper the ink.

"Though thou bray a fool in a mortar."

Bray'ing. (*Woolen-manufacture.*) The process of pounding and washing woven cloth in *scouring-stocks*, to remove the oil applied preparatory to carding; and also soil acquired in the course of manufacture.

Braz'ing. Soldering together the surfaces of iron, copper, brass, etc., with an alloy composed of brass and zinc, sometimes with the addition of a little tin or silver. The surfaces to be united must be rendered perfectly clean and bright. The alloy, in granular form, is usually wetted with ground borax and water, dried, the pieces placed in contact and exposed to the heat of a clear forge-fire, causing the solder to flow between them. This may be assisted by the use of a soldering-iron.

Bread. A mixture of flour and water, baked to the extent of suppressing its clamminess.

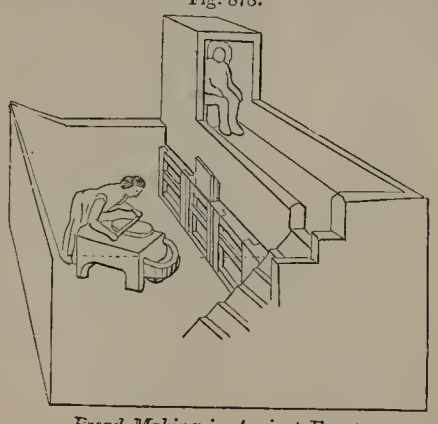
In the Old Testament we find that bread-making was a duty performed by the mistress of the family, —Sarah; by one of the daughters, — the much-abused Tamar; by servants, —as those captives referred to by Samuel, who are prospectively made to serve as "confectionaries, cooks, and bakers"; by an officer of the household, — Pharaoh's servant, the chief baker; by tradesmen, — as the bakers referred to by Hosea.

The Israelites ate leavened bread except on peculiar occasions. The Bedouin of the present day, as his ancestors did, cooks his unleavened bread in the embers, generally between layers of dung. We are not destitute of the same fuel on the Western plains, but delicately term it *bois de vache*, or, more squarely, *buffalo-chips*. When the Arab bakes a pasty bread on a pan or griddle, he calls it a *flita*. Without intending to talk Arabic, we do the same sometimes.

The Egyptian like the London bakers kneaded bread with the feet. The practice is probably more general than we know, or like to believe.

In a little model of a house found by Mr. Salt in Egypt, and now in the British Museum, a doll-woman

Fig. 878.



Bread-Making in Ancient Egypt.

stands in the court-yard in the act of rolling dough. The mixing-trough is attached at the end of the table, and the quiet little doll, which may have amused the children of the time of Moses, has maintained the position of action for near forty centuries, and is now viewed by the juveniles of a country which was alternate forest and morass for two thousand years after the little figure was started at her protracted employment.

Ching-Noung, the successor of Fohi, is reputed to have first taught the art of making bread from wheat and wine from rice, 1998 B. C. This was the era of Terah, the father of Abraham, of the shepherd kings of Egypt, and of the fabulous wars of the Titans in Greece. A few years subsequently, 1913 B. C., Melchisedek brought out wine and bread to Abram and blessed him (Gen. xiv. 18). Fifteen years afterward we find Abraham giving three strangers a morsel of bread to stay their stomachs, while his wife prepared hot cakes made out of fine meal, kneaded, and no doubt cooked in the ashes, as they had not then seen the Egyptian plan of cooking in ovens. This was served up with butter, — probably bonny-clabber or curds, — milk, and veal.

The Hebrew bread was a flat cake, baked on the hearth or on a metallic plate. It was broken, not cut, and may have had indentations to form lines of easy fracture. Thus may have arisen Paul's remark, —"We, being *many*, are *one bread*" (1 Cor. x. 17).

In the time of Pliny we find that, though bread was made from a variety of grains, yet that wheat was held in the highest estimation: the wheat of Italy ranking first for weight and whiteness, while that of Sicily, one of the granaries of Rome, stood third, Bœotian wheat being preferred to it.

He states that the weight of all commissary bread exceeded that of the flour from which it was made by one third, and this is still held to be the proper percentage of gain in well-made bread from good flour. The German proportion, stated by Köhler in his *Rechenmeister*, is 156 pounds of dough, and 153 pounds 11½ ounces of bread from 100 pounds of flour.

The Romans appear to have leavened their bread with preparations similar to that known in some places as "salt rising," instead of yeast. Pliny says that in Gaul and Spain, where they make a drink (beer) by steeping grain in water, they employ the foam which thickens on the surface (yeast) as a leaven, and that consequently the bread in those countries is lighter than that made elsewhere. He must mean in proportion to its bulk, and not that a certain quantity of flour would produce a less weight of bread.

The Roman leaven is described as being made from millet mixed with grape-juice, which it is said would keep a whole year. Fine wheat bran was also employed; this was mixed with white must (or grape-juice) three days old, then dried in the sun and made into small cakes. For making bread, these cakes were first soaked in water boiled with the finest spelt-flour, and then mixed with the dough.

These kinds of leaven could only be made during the vintage, but there was another kind, made from barley and water, which could be prepared at any time; this was made up in cakes of two pounds' weight, which were baked until they became of a reddish-brown color, when they were put in close vessels and allowed to turn sour; when wanted for leaven, they were steeped in water.

Leaven, for immediate use, was also prepared by kneading some of the flour, without salt, boiling it to the consistency of porridge, and keeping it till it began to turn sour; or the bread was leavened by means of some of the dough left over purposely from the day before, as among the ancient Hebrews.

In the maritime districts the flour was mixed with

sea-water, to economize salt; and in the preparation of some kinds of flour, according to Pliny, the bran was first taken off the berry by trituration in mortars containing brickbats and sand. His translators have rather absurdly made him say that bricks and sand were ground up with the grain. In one species of bread, called *alica*, which he mentions as being peculiarly wholesome and palatable, a species of chalk found in the hill Leucorgeum, between Naples and Puteoli, was employed for imparting whiteness and crispness.

Their bread was probably too moist for our taste, rather a pasty mass, somewhat better than the common *puls*, which resembled our paste or gruel, a sort of hasty-pudding, and which formed the staple of the farinaceous diet of the Romans.

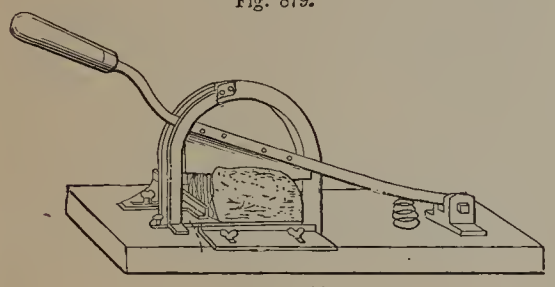
There were no professional bakers in Rome till after the war with King Perseus, more than 580 years after the building of the city. The occupation formerly belonged to the women. They ate their bread moist; it was sometimes kneaded with the must of the grape, with raisin-juice, or with butter for shortening, or with eggs and milk, and often soaked in milk and honey before eating. Vinegar, to soak the bread, was a regular ration with the Roman soldiery. It is much older than that, however: Boaz said unto Ruth, "Eat of thy bread, and dip thy morsel in the vinegar."

After the conquest of Macedon, 148 B. C., Greek bakers came to Rome and monopolized the business. Loaves of bread, or their pseudomorphs, are found in the excavations of Pompeii, partially buried A. D. 79.

Bread was made with yeast by the English bakers in 1634. Was made by machinery in England in 1858. Was artificially inflated with carbonic-acid gas, with which the water of mixing was impregnated, by Dr. Dauglish, in 1859. Aërated bread was made in the United States prior to 1854.

Bread-knife. A knife pivoted at one end to a post on a table, and used by a vertical motion to cut loaves into slices. In the example the hinged cutter plays in a slotted arched frame; an adjustable guide is adapted to the size of the loaf, and a gage determines the thickness of the slice to be cut.

Fig. 879.



Bread-Knife.

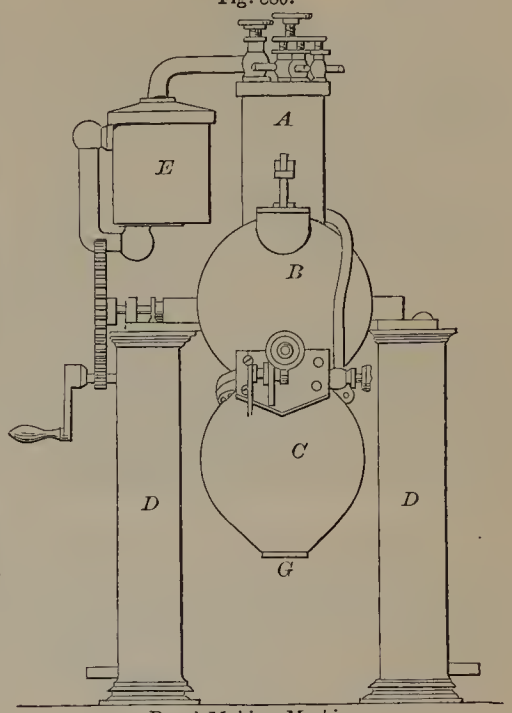
Bread-mak'ing Ma-chine'. A machine in which flour and water are mixed and kneaded. In some machines of this character the dough is rolled flat and cut into loaves, which are laid aside to rise before baking. See BREAD.

The process of making bread without leaven or yeast, generally known as aërated bread, is believed to have been first practiced with any considerable degree of success in the United States some twenty years ago. In England it appears to have been of later introduction, the process of Dr. Dauglish having first been made public in 1859. It consists in generating carbonic-acid gas in a separate vessel and mechanically forcing it into the water with which the flour is mixed.

His apparatus for making aërated bread is shown in the illustration.

The water-chamber *A* and mixer *B* are cast in one piece, and communicate by an equilibrium pipe and valved aperture; the water-chamber also communicates with a water-tank and with the gas-generating chamber *E* through pipes whose discharge is controlled by cocks operated by hand-wheels. The flour and salt are placed in the mixing-chamber *B*, and water is admitted to the water-chamber from the tank. When the gas in its chamber has attained a sufficient degree of pressure, say 100 pounds to the square inch, the cock leading to the water-chamber is turned, and the gas passes through the water, which thus becomes thoroughly charged under that high pressure, and is then admitted to the mixing-chamber, where it is mingled with the flour and salt by means of revolving mixers on a shaft rotated by gearing driven by hand-crank or a steam-engine. The receiver is secured to the mixing-chamber *B* by a bolted flange, and communicates with it through an aperture provided with a slide-valve, which is capable of a rotary as well as a reciprocating motion, by means of which any dough can be pressed out from between it and its seat. The two vessels are also connected by an equilibrium-pipe, that the pressure of gas may be equal in each, allowing the dough to fall into the mixing-chamber by its own gravity. From the receiver the dough is passed to the baking-pan, by means which allow of its being surrounded by air or gas under pressure, thus lessening the escape of the gas inclosed in the dough.

Fig. 880.



Bread-Making Machine.

The baking requires to be conducted in a peculiar manner. Cold water being used in mixing, the expansion of the dough on rising causes a great reduction of temperature, as much as 40° below that of fermented bread when placed in the oven; this, with its slow springing until it reaches the temperature of the boiling-point, renders it essential that the top crust should not be formed until the very close of the process. The furnaces, accordingly, are so arranged that the heat is applied through the bottom;

and, at the last moment, when the bread is nearly baked through, the upper heat is applied and the top crust formed.

The principles of bread making and baking have been carefully explained by Professor Horsford, of Cambridge, Mass.

Bread-rasp. A *rasp* used by bakers in removing the burned crust of loaves and rolls, especially of French rolls.

Bread-slic'er. See BREAD-KNIFE.

Breadth. (*Shipwrighting.*) The thwart measure of a ship at any designated place. The *beam* is the *extreme breadth;* that is, at the widest part.

Breadth-line. (*Shipwrighting.*) A line of the ship lengthwise, following the curve indicated by the ends of the timbers.

Break. 1. A wooden bench on which dough is kneaded by means of a lever called a *break-staff.* The weight of the person, often in a sitting posture, is thrown upon the staff, which moves in a semicircular orbit around the bench, keeping up a saltatory motion by its flexibility and the dancing action of the operator. By this means the dough is worked up very dry, and makes the best kind of crackers.

This duty is now performed by rollers, which receive their name from their duty, being called *breaking-rollers.*

2. (*Fortification.*) A change from the general direction of the *curtain* near its extremity in the construction with orillons and retired flanks. *Brisure.*

3. (*Printing.*) The piece of metal contiguous to the shank of a type, so called because it is broken off in finishing.

4. (*Architecture.*) A projection or recess from the surface or wall of a building.

5. A sudden change of level, as of a deck. The *break* of a poop-deck is where it ends forward.

6. (*Telegraphy.*) A commutator or apparatus to interrupt or change the direction of electric currents.

See BRAKE, for devices for applying power, for restraining motion, etc.

Break'er. 1. (*Nautical.*) A small cask for ship's use. Employed for bringing water aboard in boats, or for containing the water required for a boat's crew absent from the vessel on duty.

The *gang*-cask is kept on deck, and contains the drinking-water for the ship's company, being replenished from day to day from the tanks.

2. (*Flax-manufacture.*) The first carding-machine which operates upon the parcels of tow from a creeping-sheet. The *finisher* is the final carding-machine, and operates upon a *lap* formed of *slivers* of *line.*

Break-ground. (*Fortification.*) To open the trenches or begin the works of the siege.

Break'ing. (*Woolen-manufacture.*) A process in the worsted or long-wool manufacture. The combed slivers are laid upon a traveling-apron and joined endwise, to make continuous lengths.

Break'ing-down Roll'ers. (*Metal-working.*) Rollers used to consolidate metal by rolling it while hot.

Break'ing-en'gine. The first of a series of carding-machines, to receive and act on the lap from the lapper; it has usually coarser clothing than the finishing-cards. See CARDING-MACHINE.

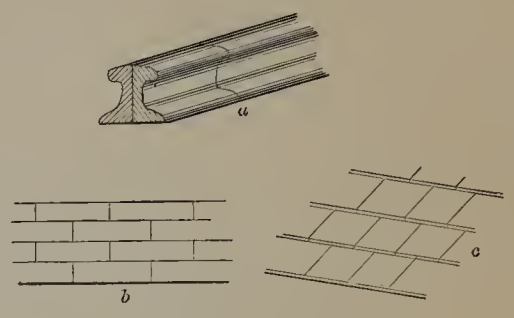
Break'ing-frame. (*Worsted-manufacture.*) A machine in which *slivers* of long-stapled wool are *planked* or spliced together and then drawn out to, say, eight times their original length. The *slivers* are made by hand-combs, and taper towards each end. Each is laid lapping half its length upon the preceding sliver, and the passage between rollers of gradually increasing speed attenuates the sliver.

Break'ing-ma-chine. (*Flax-manufacture.*) A machine for shortening flax-staple, to adapt it to be worked by a certain kind of machinery. *Long-flax* or *long-line* becomes *cut-flax* or *cut-line.* The machine is also known as a *cutting-machine* or *flax-breaker.*

Break-i'ron. (*Carpentry.*) The iron screwed on top of a plane-bit to bend upward and *break* the shaving. Its edge is from $\frac{1}{16}$ to $\frac{1}{30}$ of an inch from the edge of the cutting-bit.

Break-joint. A *break-joint* structure is one in which the joints of the parts or courses are made to

Fig. 881.



Break-Joint Rail and Courses.

alternate with unbroken surfaces, as in the continuous railroad rail, in bricklaying, shingling, and numerous other mechanic arts.

a, break-joint of a compound rail.
b, break-joint of bricks in courses.
c, break-joint of slates in courses on a roof.

Break'wa-ter. A structure or contrivance, as a mound, mole, wall, or sunken hulk, interposed to break the force of the waves and to protect an anchorage, harbor, or any object exposed to the waves.

Breakwaters for the purpose of protecting harbors are of very ancient origin.

The harbor of Alexandria was protected by a stone mole called the Heptastadium, which joined the island of Pharos and the main-land. It had two passages through it, which were spanned by bridges.

Nebuchadnezzar built quays and breakwaters along the shores of the Persian Gulf. — HERODOTUS.

The harbor of Rhodes and the Piræns of Athens were protected by moles, as were also those of Civita Vecchia, Ostia, Antium Misenus, and others among the Romans.

We are informed by Josephus, that Herod, desiring to form a port on the coast of Syria, between Joppa and Dora, caused great stones, most of them 50 feet long by 10 wide and 9 deep, and some even larger, to be cast into the sea in 20 fathoms of water, with a view of forming a foundation for a mole or breakwater.

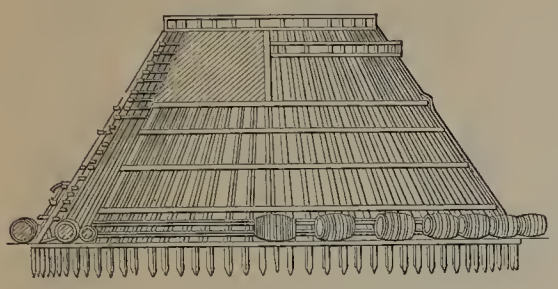
The Romans constructed the moles or breakwaters of many of their harbors upon a double row of arches, so arranged that the openings of one set were opposite the piers of the other, by which means the force of the waves was thoroughly broken, while still permitting the passage of the current, thus greatly reducing the accumulation of deposits around the base of the structure, and consequent tendency towards filling up the harbor. The piers of the new river-frontage of New York are to be constructed on pillars which allow free course to the water, being intended for wharfage, not wave-breakers.

The breakwater of Cherbourg was commenced in 1784. Its total length is 4,120 yards, consisting of two arms, respectively 2,441 and 1,679 yards long, forming an obtuse angle of 169° towards the sea. The average depth of water inclosed is 62 feet at high spring-tides, and the area sheltered is about

1,927 acres, about one third of which has a depth exceeding 27 feet at low-water spring-tides.

Cessart's plan for breakwaters at the latter part of the last century consisted of large truncated cones of timber floated by means of air-barrels lashed thereto, and towed to the spot. These were 150 feet in diameter at the bottom, 64 at the top, and

Fig. 882.



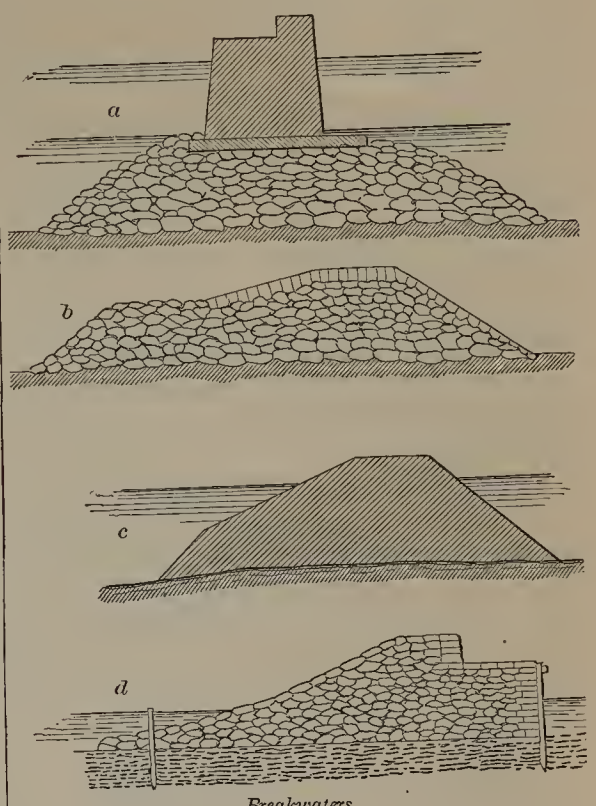
Cessart's Breakwater.

70 feet high. Ninety such cones were to be placed consecutively, to form a breakwater when sunk and filled in with stone. The project was only partially carried out. The timbers were dislocated and the stones scattered. The work was renewed by additions of stone till it reached the level of low-water spring-tides; upon these was laid a bed of hydraulic concrete five feet thick, and upon this was erected a solid wall of coursed ashlar masonry faced with granite. The top of the sea-slope is covered with large loose blocks, and at the extremities of the wings it is farther protected by immense artificial blocks, weighing about 40 tons each, formed of rubble set in hydraulic cement. Fig. 883 (*a*) shows a section of this work.

b is a section of the breakwater off Plymouth, England, to protect the harbor, which is only open to the south. It is situated upon the inner of three natural reefs of rock, which lay outside the harbor, and closes what was once a central passage, leaving open passages to the east and west. The main body is placed perpendicularly to the S.S.E., and is 1,000 yards long. Wings at each end form angles of 135°, and are each 350 yards in length. A surface of 1,120 acres is protected. It is 133 yards wide at bottom, 15 at top; a set-off 22 yards wide forms a foreshore on the sea side. The upper portion is revetted with masonry laid in Roman cement on both faces and crown. The hight of the latter is 2 feet above high-water spring-tides. 4,105,920 tons of stone were used in the construction. Cost, $7,500,000.

Delaware Breakwater is situated just inside of Cape Henlopen, the southwestern point of land at the entrance of Delaware Bay, and was intended to form a harbor of refuge during storms for vessels passing along the coast. The work was commenced in 1829. It consists of two parts, the breakwater proper and the ice-breaker. The former is 1,203 yards long, extending in an E.S.E. and W.N.W. direction. The ice-breaker is designed to protect the harbor from floating ice brought down by the Delaware River, is 500 yards long, and lies in an E. by N. and W. by S. direction, having a passage of 350 yards between it and the breakwater, the prolongation of which would pass near the center of the ice-breaker. The work protects from the more dangerous winds an area of about 420 acres, having a depth of 3 to 6 fathoms, leaving a passage of about 1,000 yards in length between the shore and its landward extremity.

Fig. 883.



Breakwaters.

The width of the structure is 175 feet at base and 30 feet at top, and it is composed of rough blocks of stone. A transverse section is shown at *c*, Fig. 882. The inner slope has an angle of 45°, the outer slope has an inclination of 3 base to 1 of hight to a depth of about 19 feet below the highest spring-tides, and from thence to the bottom of 45°.

Breakwaters have also been constructed by the United States government at several lake-ports, particularly at Buffalo and Cleveland on Lake Erie, and Chicago on Lake Michigan.

The covering pier or breakwater of Buffalo Harbor (*d*, Fig. 883) is built of stone, and cost about $ 200,000. The illustration shows a cross-section. It measures 1,452 feet in length. The top of the pier on which the roadway is formed measures eighteen feet in breadth, and is elevated about five feet above the level of the water in the harbor. On the side of the roadway which is exposed to the lake, a parapet-wall, five feet in hight, extends along the whole length of the pier, from the top of which a talus wall, battering at the rate of one perpendicular to three horizontal, slopes towards the lake. This sloping wall is formed of coursed pitching. Its foundations are secured by a double row of strong sheeting-piles driven into the bed of the lake, and a mass of rubble *pierres perdues*, resting on the toe of the slope. The quay or inner side of the pier is perpendicular, and is sheathed with a row of sheeting-piles, driven at intervals of about five feet apart from center to center, to prevent the wall from being damaged by vessels coming alongside of it.

The harbor of the city of Pernambuco, in Brazil, is defended by a natural breakwater, — a reef of hard coral just level with the sea, and extending for miles along the coast, parallel with the main-land and but a very short distance from it, leaving a narrow channel of sufficient depth to float vessels of considerable size between them.

Here ships may ride in perfect safety, the water being as smooth as a mill-pond, while the sea is breaking furiously upon the reef, even at times casting its spray on the decks of vessels moored inside.

Break'wa-ter-gla'cis. (*Hydraulic Engineering.*) A *storm pavement*. The sloping stone paving next the sea in piers or breakwaters.

Bream'ing. (*Nautical.*) Cleansing the ooze, shells, seaweed, etc., from the bottom of a ship by a flashing fire and scraping.

Breast. 1. (*Agriculture.*) The forward part of a plow's mold-board.

2. (*Carpentry.*) The lower side of a hand-rail, a rafter, the rib of a dome or of a beam.

3. (*Mining.*) The face of a coal-working.

4. (*Architecture.*) *a*. That portion of a wall between the window and the floor.

b. That portion of a chimney between the flues and the apartment.

5. (*Machinery.*) A bush connected with a small shaft or spindle.

6. (*Hydraulics.*) The curved wall up to which the floats of a water-wheel work, and which prevents, as far as possible, the waste of water.

7. (*Sheet-iron Ware.*) As applied to milk-cans, coffee and tea pots, and similar articles, this word denotes the bulging or rounded top which intervenes between the lid or cover and the cylindrical portion which forms the body of the vessel.

8. (*Vehicle.*) The *middle*, *swell*, or *bulge* of a nave or hub.

9. The front of a furnace.

10. The part of an object against which the breast pushes in some machines, such as the *breast*-drill, *breast*-plow, etc.

Breast-band. (*Saddlery.*) A band passing across the breast of the draft animal, and to which the traces or tugs are attached. It is a substitute for a collar.

Breast-beam. 1. (*Shipwrighting.*) A beam at the break of a quarter-deck or forecastle.

2. (*Weaving.*) The cloth-beam of a loom.

3. (*Railroad Engineering.*) The forward transverse beam of a locomotive.

Breast-board. (*Rope-making.*) A loaded sled to which are attached the end yarns at the foot of the walk. As the yarns are twisted into a strand they become shorter and draw the sled towards the head of the walk, the load on the sled maintaining the necessary tension. The yarns are usually shortened one third by the twisting, and lose about thirty per cent in so doing. The twist is, however, necessary, to give the requisite rigidity, to prevent the fibers sliding on each other, and to partially exclude wet. The addition of tar increases the power of excluding water.

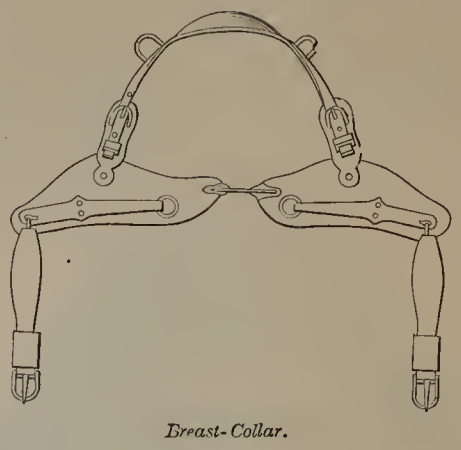
Rope not twisted, but bound tightly together, is stronger than twisted rope, but is soft and not durable, the yarns readily admitting water, which rots the rope.

Breast-chain. (*Saddlery.*) A chain reaching between the hame-rings, its loop passing through the ring of the neck-yoke, to support the tongue.

In carriage harness, the hame is destitute of the rings, and the strap is passed around the lower part of the collar. See NECK-YOKE.

Breast-col'lar. (*Harness.*) A pulling strap which passes around the breast of the horse; a substitute for a collar, which encircles the neck and rests against the shoulders. In the example the breast-strap is padded, and the two pieces are connected by a snap. A plate upon it holds the breast-rings and tug-buckle pieces.

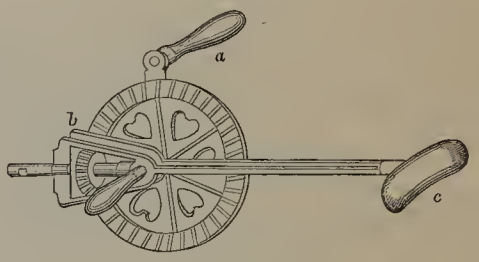
Fig. 884.



Breast-Collar.

Breast-drill. (*Metal-working.*) A drill-stock operated by a crank *a*, and bevel gearing *b*, and having a piece *c* against which the workman bears his breast when engaged in drilling.

Fig. 885.

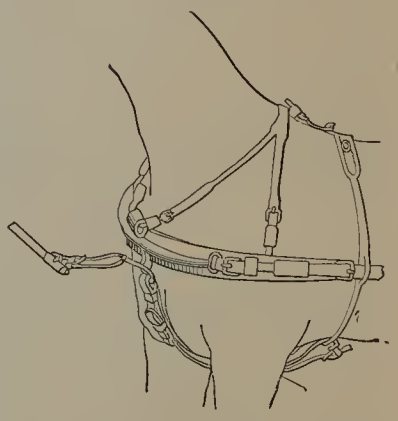


Breast-Drill.

Breast-fast. (*Nautical.*) A mooring hawser to confine the ship's broadside to a quay or wharf. *Bow* or *head fast* and *stern-fast* indicate ropes of different positions but similar duty.

Breast-har'ness. (*Saddlery.*) A horse-gear arranged to pull by a band in front of the breast, instead of a collar.

Fig. 886.



Breast-Harness.

Breast-hight. (*Fortification.*) The interior slope of a parapet.

Breast-hook. (*Shipbuilding.*) One of the curved horizontal timbers placed inside the bow as *struts* to support and *ties* to connect the sides. Also called *breast-knee*.

Breast'ing. 1. (*Mill.*) The curved masonry against which the shuttle side of a breast-wheel works, and which prevents the water from slipping past the wheel.

The scoop-wheel has also a *breasting* which confines the water raised thereby. See SCOOP-WHEEL.

2. (*Paper-making.*) The concave bed against which the wheel of a rag-engine works; between the two is the *throat*. See RAG-ENGINE.

Breast-line. The rope connecting the pontons of a military bridge in a straight direction.

Breast-mold'ings. (*Carpentry.*) Window-sill moldings. Panel moldings beneath a window.

Breast-plate. 1. A plate which receives the hinder end of a drill, and by which pressure is applied. Formerly held against the breast, it still retains its name, even when otherwise supported. A *conscience* or *palette*. See BREAST-DRILL.

2. Armor for the breast. The forward portion of a cuirass.

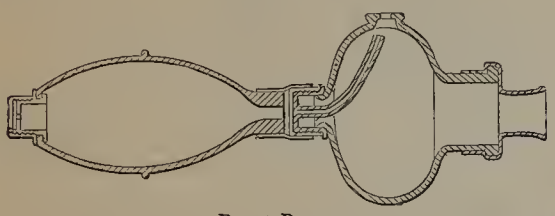
Breast-plow. (*Husbandry.*) A shovel whose handle has a cross-piece applied to the breast, and used for paring turf or sods.

Breast-pump. (*Surgical.*) Also known as *antlia lactea* or *antlia mammaria*.

A pump having a cup adapted to fit over the nipple, in order to withdraw milk from the *mamma* when this cannot be effected in a natural way.

In one example the receiver has an opening which in use is covered by the thumb and serves as an exit for the milk. The air is drawn off through an up-

Fig. 887.

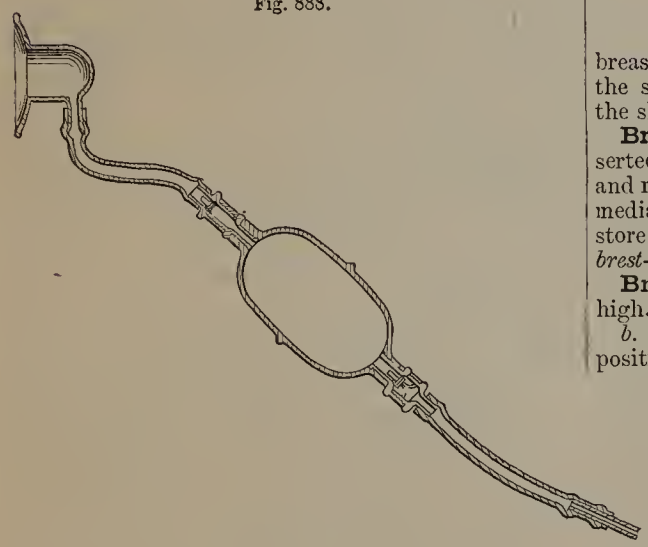


Breast-Pump.

turned tube, which prevents the access of liquid to the valves. The valves consist of two cylindrical flanged caps, whose ends are perforated and inclose between them a valve-disk of rubber.

In the other example the suction-nipple is of rigid material, and has side discharge into the flexible pipe

Fig. 888.



Breast-Pump.

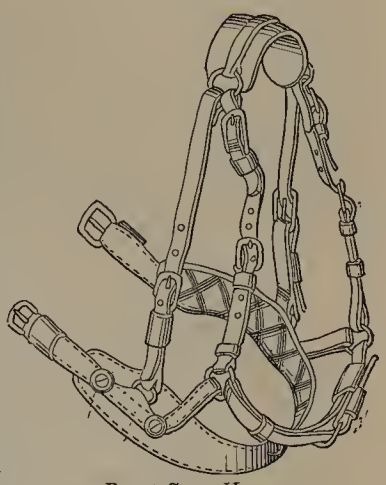
communicating with the elastic bulb. The latter has induction and eduction valves.

Breast-rail. (*Shipwrighting.*) The upper rail of a balcony or of a breastwork on the quarter-deck.

Breast-strap. (*Saddlery.*) A strap passing from the *hame-rings* or from the *gullet* of the collar, to support the tongue or pole of the vehicle.

Breast-strap Har'ness. (*Saddlery.*) That which has a strap around the breast instead of a collar. In the example the breast-collar is supported as usual from the withers, and at its rear ends receives the tug-straps. Other forward attachments are made to the breast-straps, which are connected to the neck-yoke or tongue.

Fig. 889.



Breast-Strap Harness.

Breast-strap Slide. (*Harness.*) An iron loop which slips on the breast-strap, and takes from the latter the wear of the ring on the end of the neck-yoke. The ends of the breast-strap are passed through the rings on the harness.

A detachable tongue or pin, made with a double point and a flange at the center, engages with the

Fig. 890.

Breast-Strap Slide.

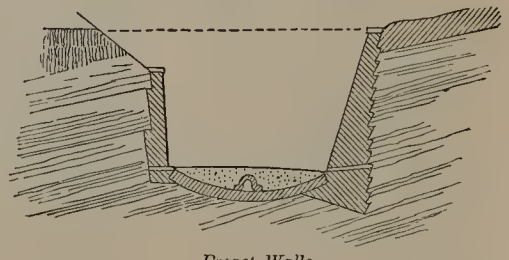
breast-strap when the slide is to be held fixedly on the strap, and is removed when it is desired that the slide should yield or play on the breast-strap.

Breast-sum'mer. (*Carpentry.*) A beam inserted flush with the house front which it supports, and resting at its ends upon the walls and at intermediate points upon pillars or columns. Common in store fronts. Written also (incorrectly) *bres-summer*, *brest-summer*.

Breast-wall. (*Masonry.*) *a*. One built breast-high.

b. A wall erected to maintain a bank of earth in position, as in a railroad cutting, a sunk fence, etc.

Fig. 891.



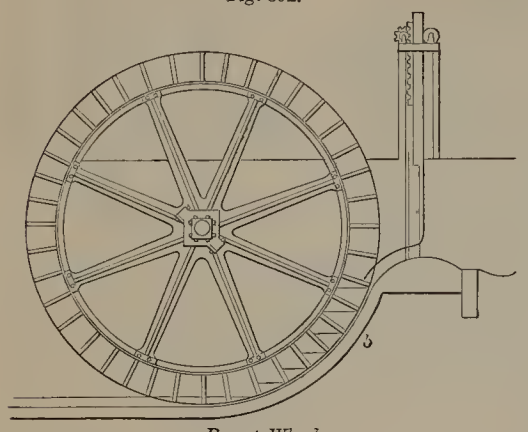
Breast-Walls.

The thickness and batter of the breast-wall depend upon the character and inclination of the strata. It is held to be a safe rule to make the base of the wall not less than one fourth, and the *batter* not less than one sixth, of the vertical hight of the wall.

Where the strata are horizontal, a mere casing may be sufficient, but its strength must be considerably increased when the strata incline towards the wall. The thickness required will also depend upon considerations of the cohesion of the earth, dryness, or tendency to moisture, drainage, and the peculiar superposition and dip of strata indicating land-slips.

Breast-wheel. A wheel to which the water is admitted about on a level with the axle, and maintained in contact with it by a *breasting* (*b*), or casing, which incloses from 60 to 90° of the periphery of the wheel. The wheel may have radial or hollow buckets.

Fig. 892.



Breast-Wheel.

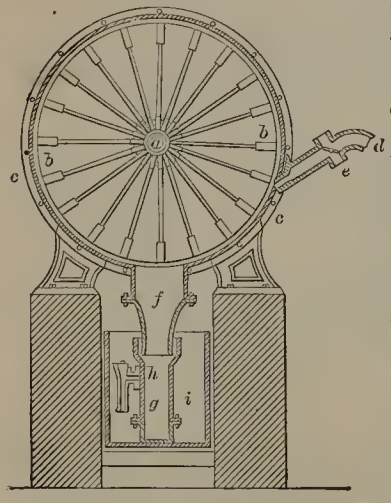
The peripheral inclosure is sometimes called *breasting*, or *soleing*, and the casing at the ends of the wheel is called *shrouding*.

Breast-wheel Steam-en'gine. A form of *rotary steam-engine* in which a jet of steam is made to impinge upon the floats of a wheel rotating in an air-tight case.

The first steam-engine of this class was one of the earliest on record. Brancas, A. D. 1520, had a copper boiler and eduction-pipe, the steam issuing from which rotated the vanes of a shaft, which (*on dit*) worked pestles for grinding materials, raising water by buckets, sawing timber, etc.

Corder and Locke's *breast-wheel engine* is one form of the rotary steam-engine, having neither piston nor valves. It consists of a wheel rotating in an air-tight case, receiving a jet of steam introduced in a tangential direction, the case having free communication with a condenser. The action upon the wheel is analogous to that of water upon a breast-wheel, the steam impinging with a force determined by its pressure and with an effect proportionate to the size of the float or bucket upon which it acts.

Fig. 893.



Corder and Locke's Rotary Steam-Engine.

The action of the condenser is auxiliary; making a partial vacuum in the case, increasing the absolute pressure of the steam, which passes in to fill the void. The shaft of the wheel passes through stuffing-boxes at the center of the circular case, and is supported externally by bearings.

a is the engine-shaft.
b, the revolving wheel.
c, the air-tight steam-case.
d, the steam-pipe.
e, the throttle-valve.
f, the eduction-pipe.
g, the condenser.
h, the injection-cock.
i, the cold-water cistern.

The condensing apparatus has the usual pumps, not shown in the cut.

Breast'work. 1. (*Fortification.*) A hastily constructed parapet made of material at hand, such as earth, logs, rails, timber, and designed to protect troops from the fire of an enemy.

2. (*Shipbuilding.*) A railing or balustrade standathwartships across a deck, as on the forward end of the quarter-deck or round-house.

The beam supporting it is a *breast-beam*.

3. The parapet of a building.

Brec'cia. (*Masonry.*) A kind of marble composed of a mass of angular fragments, closely cemented together in such a manner that when broken they form *brèches* or notches.

Breech. 1. (*Fire-arms and Ordnance.*) The rear portion of a gun; the portion behind the chamber.

2. (*Shipbuilding.*) The outer angle of a knee-timber; the inner angle is the *throat*.

Breech-block. A movable piece at the breech of a breech-loading gun, which is withdrawn for the insertion of a cartridge and closed before firing, to receive the impact of the recoil. This is the great problem in the breech-loading gun. Under Fire-arm the subject is treated, the invention being divided into 2 genera, 91 species, and 21 varieties, according to the mode of moving the block relatively to the barrel or the barrel to the block. The problem is to open the rear of the barrel and close it again. See Fire-arm.

Breech'ing. 1. (*Ordnance.*) A rope secured by a thimble to the breeching-loop of a ship's gun, and attached by its ends to ring-bolts on each side of the port-hole, serving to limit the recoil of the gun when fired.

The *breeching-loop* occupies the place of the ordinary *cascabel*.

2. (*Harness.*) The portion which comes behind the buttocks of a horse, and enables him to hold back the vehicle in descending a hill.

3. A bifurcated smoke-pipe of a furnace or heater.

Breech'ing-hook. (*Vehicle.*) A loop or hook on the shaft of a carriage for the attachment of the strap of the breeching, by which the horse bears backwardly against the load in descending a hill.

Breech'ing-loop. The loop of the cascabel in ships' guns, through which the breeching goes to prevent the recoil.

Breech-load'er. A fire-arm in which the load is introduced at the rear instead of at the muzzle. The use of breech-loaders goes back to the sixteenth century; indeed, it is probable that that form of arm is about as old as the muzzle-loader. See Fire-arm; Revolver; Magazine-gun; Cannon. See also list under Weapons.

Breech-pin. (*Fire-arms.*) A plug screwed into the rear end of a barrel, forming the bottom of the charge-chamber. Otherwise called a *breech-plug* or *breech-screw*.

Breech-screw. (*Fire-arms.*) The plug which closes the rear end of the bore of a fire-arm barrel. The parts are known as

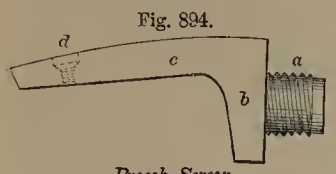


Fig. 894.
Breech-Screw.

a, plug.
e, face.
b, tenon.
c, tang.
d, tang-screw hole.

Breech-sight. (*Fire-arms.*) The hinder sight of a gun. In conjunction with the front sight it serves to aim the gun at an object. It is graduated to degrees and fractions, their length on the scale being equal to the tangents of an arc having a radius equal to the distance between the front and rear sights. The front sight is merely a short piece of metal screwed into the gun, usually at the muzzle, but sometimes between the trunnions, or on one of the rimbases, with its upper edge parallel to the bore of the gun. The rear sight may be detached, having a circular base fitting the base of the gun, or may slide through a slotted lug, and be retained at any given hight by a set screw.

The *breech-sight*, the *tangent scale*, and the *pendulum* are merely different forms of this device, the latter having a bulb at its bottom which keeps it in a vertical position when the two wheels of the carriage are not at the same level. It is suspended in a seat which is screwed into the breech of the gun. The tangent scale has steps, corresponding in hight to the graduations on the breech sight for guns of the same caliber and pattern; and is only applied to the gun at the moment of sighting. See BACK-SIGHT.

Breech-wrench. A wrench used in turning out the breech-pin of a fire-arm.

Breeze. (*Brick-making.*) Refuse cinders used for burning bricks in the clamp.

Breeze-ov'en. A furnace adapted for burning coal-dust or *breeze*.

Bre-luche'. (*Fabric.*) A French floor-cloth of linen and worsted.

Bre-quet'-chain. A chain for securing the watch in the vest pocket to a button or button-hole of the vest.

Bres'-sum-mer. (*Carpentry.*) A girder in an external wall, supported by piers or pillars, and carrying a superincumbent weight. Sometimes written *brest-summer*; properly, *breast-summer*.

Brett. (*Vehicle.*) A four-wheeled carriage having a calash top and seats for four besides the driver's seat. A short term for *britzska*.

Bret'tice. (*Mining.*) *a*. A vertical wall of separation in a mining-shaft which permits ascending and descending currents to traverse the respective compartments, or permits one to be an upcast or downcast shaft, and the other a hoisting shaft; otherwise written *brattice*.

b. A boarding in a mine, supporting a wall or roof.

Breve. (*Printing.*) A curved mark ("⏑") indicating the short quantity of a vowel; as, — Ĕp'i-grăm.

(*Music.*) A note in music ("𝅜") of the value of four minims.

Bre-vier'. (*Printing.*) A size of type between bourgeois and minion.

Bourgeois, 102 ems to the foot.
Brevier, 112 ems to the foot.
Minion, 128 ems to the foot.

Brew'ing. The art of preparing fermented liquors from grain. Herodotus, who wrote about 450 B. C., says that the Egyptians made their "wine" from barley, and ascribes the invention to Isis, wife of Osiris. The Greeks used a malt liquor under the name of barley wine, having learned the art of making it from the Egyptians. It is mentioned by Xenophon, 401 B. C. According to Tacitus, beer was a common drink among the Germans, and Pliny says that in his time all the nations of the West of Europe made an intoxicating liquor from grain and water. The description given by Isidorus and Orosius of the manner of its preparation in Britain and other ancient Celtic countries, applies precisely at the present day, so far as the infusion of malt is concerned, but no mention is made of the use of hops. These do not appear to have been used by the Greeks, Romans, or early Germans, though the plant grows wild in Europe. It is first mentioned in a letter of Pepin (A. D. 752), who speaks of *humulonariæ* (hop-gardens). It is again referred to by Adelard, Archbishop of Larby, 822.

Hops, pressed into masses like bricks, have been placed by the Chinese in their beer from time immemorial. The same custom is, or was, practiced in Bohemia. They were introduced into England by a native of Artois about the beginning of the fifteenth century, but their use was opposed by physicians from the supposition that they made the beer unwholesome. The cultivation was forbidden by acts of Henry VI. and Henry VIII., but eventually survived this injurious legislation.

The manufacture of beer must have been carried on to a considerable extent among the Anglo-Saxons, as ale is mentioned in the laws of Ina, king of Wessex, and at after periods.

Malting is the first step in the process of making fermented liquors from grain, and for this any of the cereals, such as wheat, oats, buckwheat, rice, or Indian corn, may be employed, but the preference has been universally given to barley.

The barley is steeped, to saturate and swell the grain, laid in piles to germinate, being spread and turned to allow access of air; when the stem or *acrospire* has nearly reached the end of the kernel, the germination is stopped by heating the malt in a kiln. The roots fall off in the drying and screening.

The malt is coarsely ground and mashed in water at a heat of 160° or 170°, dissolving the sugar developed by the malting, and allowing the diastase to act upon any remaining starch which has continued unchanged. Water at 194° is added to complete the infusion, and the *wort* is drawn off. Successive amounts of water remove remaining soluble matter. A saccharometer is used to test the strength of the infusion, which is then boiled with hops in a copper boiler. It is then strained, cooled, yeast added, allowed to ferment, transferred to storage-vats, or drawn off at once into barrels.

Brew-ket'tle. (*Brewing.*) The vessel in which the wort and hops are boiled.

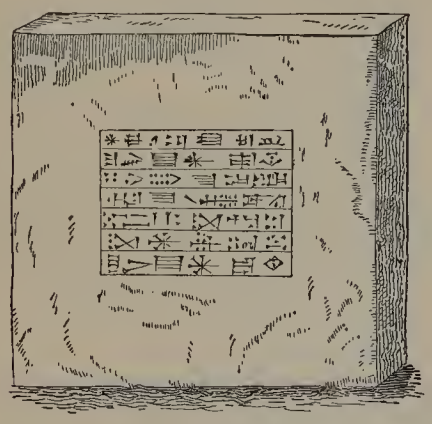
Bri'ar-tooth. Properly BRIER-TOOTH (which see).

Brick. A molded and burned block of tempered clay. The word is also applied to the block in its previous conditions, as a molded plastic mass, and as a *dried* block in which the water, hygrometrically combined with the clay, is driven off. When this condition is accepted as a finality, the block so dried is an adobe. The *burning* of the previously *dried* brick drives off the chemically combined water, and forever changes the character of the mass. An adobe may become re-saturated with water, and resume its plasticity; a brick may become rotten and disintegrated, but not plastic.

Travelers on the Euphrates give extraordinary accounts of the mounds of bricks at Birs Nimrod,

the supposed site of Babylon, and the remains of other cities of the stoneless plains of the Euphrates and Tigris. The men on the plains of Shinar who said, "Go to, let us make brick, and burn them thoroughly" (Gen. xi. 3; 2247 B. C.), and who laid them up with slime (bitumen), made a very thorough job of it, if the true site has been found. Rawlinson, Layard, Mignau, Rennel, and many others, have found at various places sun-dried and kiln-burned brick of large size and in inealculable quantity. The buried palace of Nebuchadnezzar has for a long series of years, indeed, provided bricks for all the buildings in the neighborhood; there is scarcely a house

Fig. 895.



Babylonish Brick.

in Hillah which is not almost entirely built with them.

"It was the custom of Nebuchadnezzar to have his name stamped on every brick that was used during his reign in erecting his colossal palaces. Those palaces fell to ruins, but from the ruins the ancient materials were carried away for building new cities; and in examining the bricks in the walls of the modern city of Baghdad, on the borders of the Tigris, Sir Henry Rawlinson discovered on each the clear traces of that royal signature." — MÜLLER, "Science of Language." See also "Researches of Della Valli," 1616; and Rich, 1815.

These bricks are red or pale yellow, and are sometimes disposed in mosaic. Their sizes vary $12 \times 12 \times 3$ inches to $19\frac{1}{2}$ inches square and $3\frac{1}{2}$ thick. Some are rounded at the corners for quoins or special work. The bricks are almost universally stamped out of a mold, and impressed with cuneiform inscriptions in a sunken rectangular panel.

The inscription on the brick (Fig. 895) is, —

> "Nebuchadnezzar
> the King of Babylon,
> founder of Beth-Digla, or Saggalu,
> and of Beth-Tzida,
> son of Nepolalazar."

From their peculiar form, the pressed cakes of tea which form so important a part of the Tureoman and Calmuck *cuisine* are known as *brick tea*.

Herodotus (450 B. C.), who had heard of this species of food, supposed it to be a kind of fruit, dried and pressed. He says: "The juice which runs off is black and thick, and is called by the natives [Seythians] *aschy*. They lap this up with their tongues, and also mix it with milk for a drink; while they make the lees, which are solid, into cakes, and eat them instead of meat." — HERODOTUS, IV. 23.

Their deseendants do the same to this day.

The bricks of Thothmes III. are impressed with his cartouche. The Roman brickmakers had their special marks. The Twenty-second Legion has been traced through Germany by the bricks which bear its name. Roman bricks are found at Caer-leon, in England, inscribed LEG. II. AUG. Bricks at York, England, attest the presence there of the Sixth and and Ninth Legions.

Of the Egyptian bricks, the following proportions are given by Wilkinson: —

	A brick of Thothmes III.	One of Amounopt III. (in British Museum).	One from the Pyramid of Howara.
Length	12 in.	11.3 in.	17 in.
Width	9	5.8	8.8
Thickness	$6\frac{2}{3}$	3.9	3.8
Weight	$37\frac{10}{16}$ lbs.	13 lbs.	$48\frac{15}{16}$ lbs.

Enameled bricks, brightly colored, are abundant in the mound of the Mujellibeh, in Mesopotamia. The principal colors are a brilliant blue, red, a deep yellow, white, and black.

The bricks in the Pyramids of Dashour are adobe, 16 inches long, 8 wide, and $4\frac{1}{2}$ thick; some made with straw and some without.

The mud of the Nile is the only material in Egypt for brickmaking, and the modern process is the same as the ancient, as may be seen by the drawings

Fig. 896.

Ancient Egyptian Brickmakers (Thebes).

on the tombs. The annexed cut is from a painting on a tomb in Thebes.

Some of the men (*a b c d*) are represented digging and mixing clay and mud; others are carrying clay (*e*), and dipping water from the river (*g*), and carrying it in jars; while others are molding bricks (*h i*), and laying them out on the ground to dry. *j k* are carrying bricks; *l* returning with his yoke empty;

m n are taskmasters. The modern plan is the same; a bed is made into which mud and water are thrown, together with large quantities of cut straw. This is tramped into a mortar, taken out in lumps, and shaped in molds, or by the hands. It is sun-dried, not burned. The bricks of Egypt, ancient and modern, are adobes.

The business of brick-making is believed to have been a royal monopoly in Egypt, and Wilkinson states that more bricks are found in Egypt with the stamp of Thothmes III. than of any other monarch. He is believed to be the prince who reigned at the time of the Exodus of the Hebrews.

A pyramid of brick was erected by Asychis, who, according to Herodotus, preceded the king who was dispossessed by Sabaco the Ethiopian, and who was restored and eventually succeeded by Sethos, a contemporary of Sennacherib and Tirhakah, about 700 B. C. Four pyramids of this material, according to Wilkinson, still remain in Lower Egypt, independent of several smaller ones at Thebes. Two are close to Memphis and the modern town of Dashoor; the others stand at the entrance to the Fyoom. They are built of adobes, and their chambers have arched brick ceilings; but the arch was long previously used in Thebes, and was invented and used in Upper Egypt many centuries before Asychis.

No trace of a burned brick has been found of the ancient age represented by the tumuli-builders of North America.

Strabo speaks of bricks made of an earth at Pitane, in the Troad, so light that they swam in water. Poseidonius speaks of bricks made in Spain "of an argillaceous earth wherewith silver vessels are cleansed [rottenstone], and so light as to float in water."

The Roman bricks, in the time of Pliny, were of three sizes, the largest a foot and a half in length by a foot in breadth, and called the Lydian. The names of the others were derived from their being respectively four and five palms in length. He cites the great use of them by the Greeks, and declares them unfit for use in Roman dwellings, where no party walls were allowed to exceed a foot and a half in thickness, and that thickness, he declares, "would not support more than a single story." The buildings in Rome were limited by Augustus to a hight of seventy feet. If Pliny could see some of our modern walls of six-story hight, he would tremble for the occupants. The inference is that wood was the principal material for building in Rome, and this view is confirmed by the extent and destructiveness of their fires. He farther cites that the walls of Babylon were of brick cemented with bitumen, and that the latter was imported from thence into Rome as a medicinal agent, and a material for varnishing heads of nails and various other articles of iron.

The Romans used large, thin bricks or wall-tiles as a bond in their rubble constructions, and such continued to be used in England until regular masonry was introduced shortly before the Norman Conquest, 1066. After the great fire of London, 1666, brick was substituted for wood in the erection of buildings in London.

The ancient nations excelled in the quality of their bricks, which was probably owing to the abundance of labor, good sunshine, and patience. The thorough working and tempering of the clay, to develop its plastic quality, followed by good drying, lengthened seasoning, and careful burning, will account for the quality. In China, the potters work up the clay provided by their fathers, and lay up a store to ripen for their children. Brickmaking in Greece was placed under legal supervisors.

The walls of the city of Athens, we learn from Pliny, were made of brick on the side towards Mt. Hymettus. Many of their other public buildings were of brick, as were also those of the Romans. An attempted enumeration would become tedious. The palaces of Crœsus, king of Lydia (548 B. C.), of Mausolus, of Halicarnassus (352 B. C.), the Bath of Titus (A. D. 70), the Pillar of Trajan (A. D. 98), and the Bath of Caracalla (A. D. 212), were of brick. The latter yet bears witness to the quality.

Among many of the Asiatic nations the bricks are of excellent quality. Those of China are faced with porcelain, and in Nepaul they are ornamented by the encaustic process and in relief.

The conquerors of Peru found the art of brick-making in a flourishing condition in the Empire of the Incas, and both there and among the more northerly countries of Yucatan and Mexico, we learn from the Spaniards, and from Humboldt, and also from our own historians and travelers, Prescott, Stephens, and Squier, that the architectural remains of former races are still extant in brick as well as in porphyry and granite.

Bricks were made in England by the Romans A. D. 44. Made under the direction of Alfred the Great, A. D. 886. The manufacture flourished remarkably under Henry VIII. and Elizabeth. The size was regulated by Charles I., 1625.

The operations of brickmaking may be said to consist in —

Preparing the brick-earth. Drying.
Tempering. Burning.
Molding.

The qualities of bricks may be thus enumerated: —

Soundness; that is, freedom from cracks and flaws.

Hardness; to enable them to withstand pressure and strain.

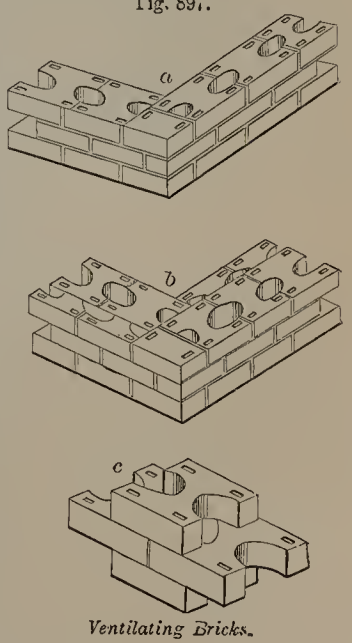
Regularity of shape and size; to enable them to occupy their proper place in the course.

Infusibility; in those intended for furnace-work.

Fire-bricks are made from a compound of silica and alumina, and the clay owes its refractory quality to the absence of lime, magnesia, potash, and metallic oxides, which act as fluxes.

Hollow bricks are made for purposes of warming, ventilating, and removing moisture from the wall. In some cases the hollows form flues, or shafts for ventilation, or discharge of dust from the upper stories. In other cases the hollows have no mechanical function other than to form air-chambers for warmth, as it is well known that an imprisoned body of air is a very poor conductor of heat. Prince Albert's tenements at Knightsbridge were built of hollow bricks, and were held to be a success in this respect.

Fig. 897.



Ventilating Bricks.

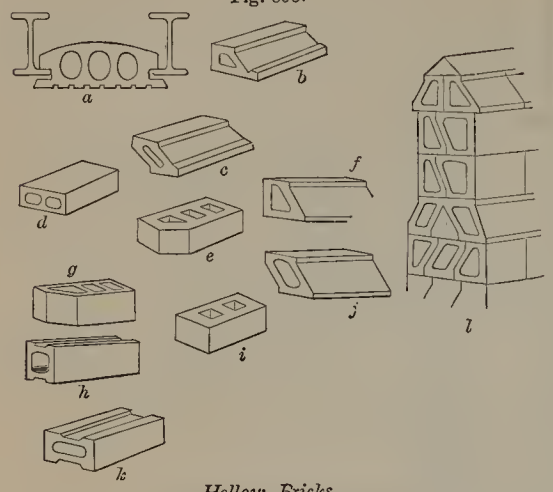
a (Fig. 897) represents a 9-inch wall finished with a common brick at the angle.

b shows a 14-inch wall, a half-ventilating brick being used alternately in the courses.

c shows the relation to each other of the ventilating spaces, so as to make the openings continuous.

Hollow bricks were used by the Romans in large vaultings, and are said to be common in Tunis, Africa. They are made by machines similar to the tile-machines or by hand. They are made of various shapes, to suit ordinary wall-work, angles, reveals, jambs, chimneys, floors, arches, copings, etc.

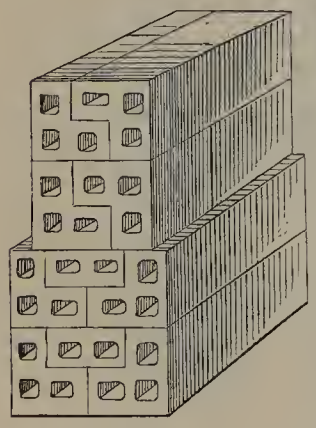
Fig. 898.



Hollow Bricks.

a is a hollow brick for ceilings, having lips which rest on the lower flanges of the girders. The bricks indicated by letters *b* to *k* are of various forms, and their uses are indicated by the section of parapet wall shown at *l* and by Fig. 899. They are external and internal, quoin, jamb, and splay bricks.

Fig. 899.



Hollow Bricks.

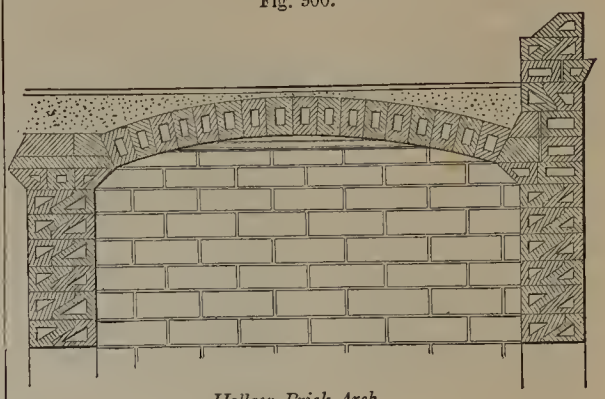
Fig. 899 is a section illustrative of the construction adopted in Prince Albert's model houses. The span of the arches is increased over the living-rooms to 10 feet 4 inches with a proportionate addition to their rise. The external springers are of cast-iron, connected by wrought-iron tie-rods.

It is stated that there is an advantage of 29 per cent in favor of the hollow bricks over the ordinary bricks, in addition to a considerable diminution in the cost of carriage or transport, and 25 per cent on the mortar and the labor.

Bricks are glazed or rendered waterproof by a composition which gives them a vitreous surface. This is performed by treating the surface with a flux which melts the silex of the brick, or it may be applied to the surface in solution, the liquid being afterwards expelled by heat. Resinous compounds have also been used to render the surface non-absorbent. They have also been treated with soluble silicate of soda, which has been decomposed, leaving the insoluble silex in the pores of the brick. Pigments added to the glazing compounds give an ornamental appearance. See BRICK-MACHINE.

Varieties of bricks are known by names indicative of material, quality, shape, and purpose.

Fig. 900.



Hollow-Brick Arch.

Air-brick is a grating the size of a brick, let into a wall to allow the passage of air.

Arch-brick usually means the hard-burned, partially vitrified brick from the arches of the brick-clamp in which the fire is made and maintained.

A brick made voussoir-shaped is known as a *compass*-brick.

A *capping*-brick is one for the upper course of a wall.

Clinker ; a brick from an arch of the clamp, so named from the sharp glassy sound when struck.

A *compass*-brick ; one voussoir-shaped for arches.

A *coping* brick ; one for a coping course on a wall.

Feather-edged brick, of prismatic form, for arches, vaults, niches, etc.

Fire-brick made of intractable material, so as to resist fusion in furnaces and kilns.

Hollow-brick, with openings for ventilation.

Stocks ; a name given locally to peculiar varieties, as gray-stocks, red-stocks, etc.

Pecking, place, sandal, semel brick, are local terms applied to imperfectly burned or refuse brick.

Bricks vitrified by excessive heat are termed *burr-brick.*

The specific gravity (average) is 1.841 ; the weight of a cubic foot, 115 pounds, which absorbs $\frac{1}{15}$ of its weight of water ; the cohesive force of a square inch is 275 pounds (Tredgold) ; it is crushed by a force of 562 pounds on a square inch (Rennie).

Weight of a cubic foot of newly built brick-work is 117 pounds ; the weight of a rod of new brick-work is 16 tons.

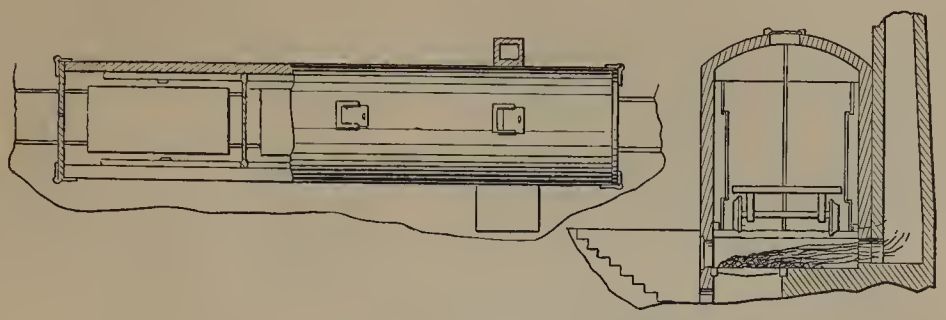
Brick-axe. (*Bricklaying.*) An axe with two ends, which are presented like chisels. It is used in chopping off the soffits of bricks to the saw-kerfs, which have been previously made in the brick to the required depth, in order to prevent the brick from *spalling.*

It is used generally in dressing bricks to a shape for arches, niches, domes, etc.

Brick-clamp. A stack of bricks in order for burning.

Bricks are burned in clamps and kilns. The former is commonly adopted in the neighborhood of London, where the *breeze* is mixed with the clay and forms the fuel by which the brick is burned. A clamp is also the name given to a pile of bricks which are built into the proper form for firing. Many variations in the modes of building clamps will be found in different places, but one successful method may be described in general terms as consisting of a number of walls or "necks," 3 bricks thick, about 60 bricks long, and 24 to 30 bricks wide, in an inclined position on each side of an upright or double battering-wall in the center of the clamp, the up-

Fig. 901.



Brick-Drying House.

right being of the same hight as the necks, but diminishing from 6 bricks thick at bottom to 3 bricks thick at top. The sides and top of the clamp are cased with burned brick, and are sometimes daubed with clay. "Live" holes or flues are made throughout the length of the clamp for the reception of the kindling when the bricks are burned with layers of breeze. In cases where they are burned by regular firing, the bricks are so clamped that openings are left for the fire in every direction. The outer layers are "close bolted," as it is called, which means that they are laid as close as possible; when they are stacked so as to allow intervals or spaces, they are said to be "scintled."

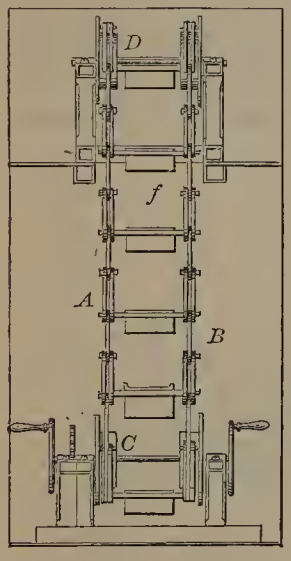
For details and particulars see "Dobson on Brickmaking."

Brick-dry'er. An oven in which green bricks are dried, so as to fit them for building up in clamps or kilns for burning.

A series of drying-chambers are separated from each other by iron folding-doors, through which chambers a railroad track is laid. Under one end of the structure is a furnace, and hot air, of increasing degrees of temperature, is introduced successively into the separate chambers.

Brick-el'e-va'tor. An apparatus for raising materials used in construction. In that shown, the endless chains *A B* are carried over wheels *C D* above and below, and the material is carried up on boxes supported by frames attached to the chains.

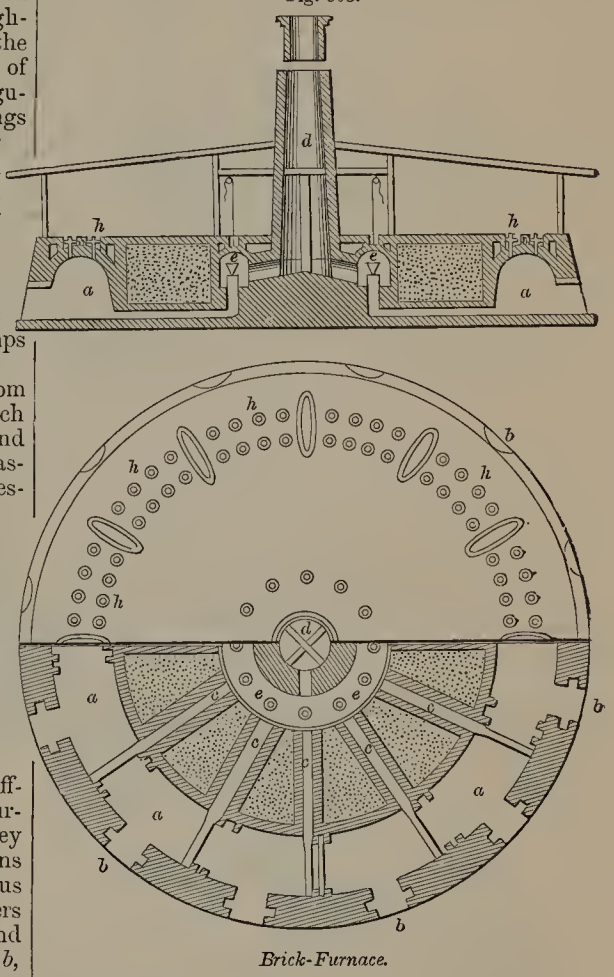
Fig. 902.



Brick and Mortar Elevator.

Brick-fur'nace. Hoffman's annular brick-furnace has a central chimney *d* and removable divisions for separating the annulus into different chambers *a a*. These are filled and emptied through doors *b*, and *c c* are valved passages leading to the drum *e* around the chimney *d*. *h h* are openings to introduce powdered coal into the chambers *a* on top of the bricks. The chambers *a a* being charged with brick, heat is applied to one chamber, and the volatile results are led through the next one, so as to heat and dry the bricks in the next in series. The bricks in chamber one being burned, the fire is applied to number two, and the heated air led therefrom through chamber three to the outlet *c* and chimney *d*. The air to feed the fire in chamber two is led through chamber one to cool the bricks.

Fig. 903.



Brick-Furnace.

Brick'ing. The imitation of brick-work on a plastered or stuccoed surface.

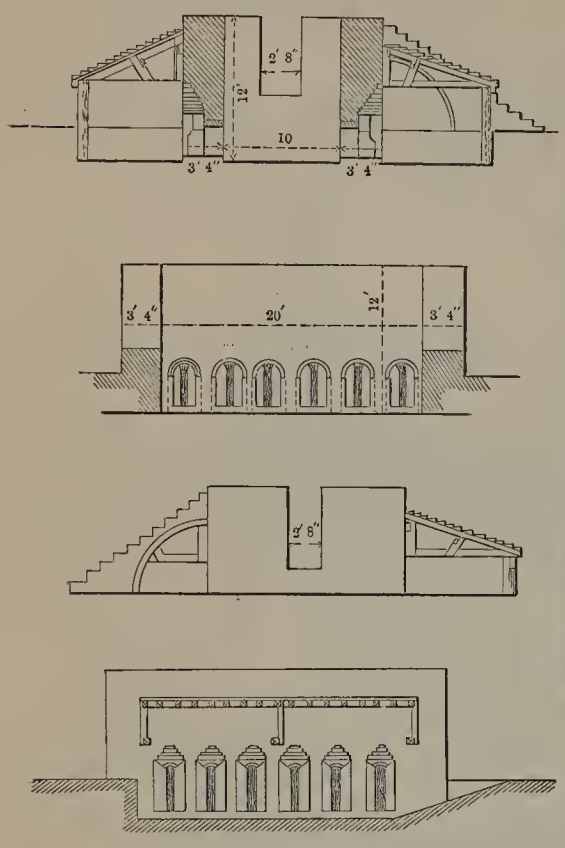
Brick-kiln. A chamber in which green bricks are loosely stacked, with spaces between them for the passage of the heat, and in which they are burned by fires placed either in arched furnaces under the floor of the kiln, or in fire-holes placed in the side walls.

One form consists of four upright walls inclosing a rectangular chamber. The floor is sunk about four feet below the general surface of the ground, and is not paved. The doorways for setting and drawing the kiln are merely narrow openings at the side of the kiln raised a step above the ground, and about

five feet from the floor. The fire-holes are arched openings oposite to each other on the sides of the kiln, lined with fire-bricks, which require to be renewed from time to time, generally every season. The width of these holes is reduced to the required space by temporary piers of brick-work, so as to leave narrow openings about eight inches wide and three feet high.

On each side of the kiln a pit is sunk to the level of the floor, and covered with a lean-to roof, which

Fig. 904.



Brick-Kiln.

protects the fuel and the fireman from the weather, and prevents the wind from setting against the fires. The walls of the kilns are about three feet thick, and are built of old bricks, rubble-stone, and the refuse of the yard. No mortar is used, as the use of lime would destroy the brick-work, and the bricks are set in loam or fire-clay.

The views (Fig. 904) represent respectively, —

A section through the sides.

A section through the ends.

An end elevation.

A side elevation.

The circular kiln or cupola (Fig. 905) is domed over at the top, whence its name is derived. The fire-holes are merely openings left in the thickness of the wall, and are protected from the wind by a wall built round the kiln at a sufficient distance to allow the fireman room to attend the fires. These cupolas are employed in Staffordshire, England, and vicinity, and the heat attained in them is very great.

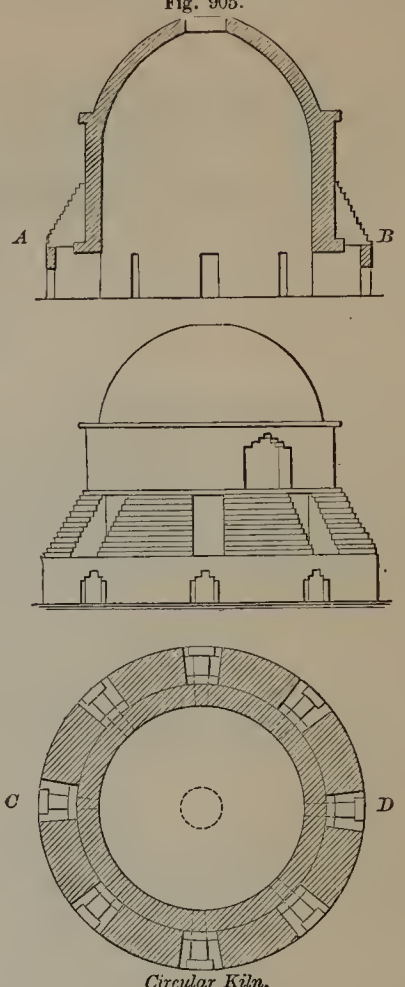
In the illustration the figures are respectively, —

A section on line *C D*.

An elevation.

A plan at top of fire-holes at level *A B*.

Fig. 905.

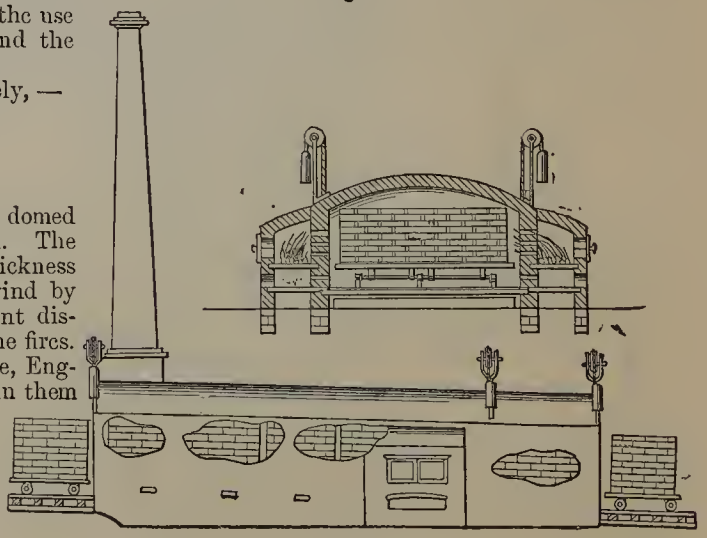


Circular Kiln.

Fig. 905 shows a progressive burning and cooling kiln, in which furnaces are arranged on each side of a chamber, in which latter are rails for carriages loaded with brick. Doors are provided at each end of the kiln, so that, when the brick on one carriage is burned, the doors are raised and a carriage of unburned brick is pushed against the others in the kiln, thus forcing out the carriage at the other end.

Air or steam have been introduced under pressure

Fig. 906.

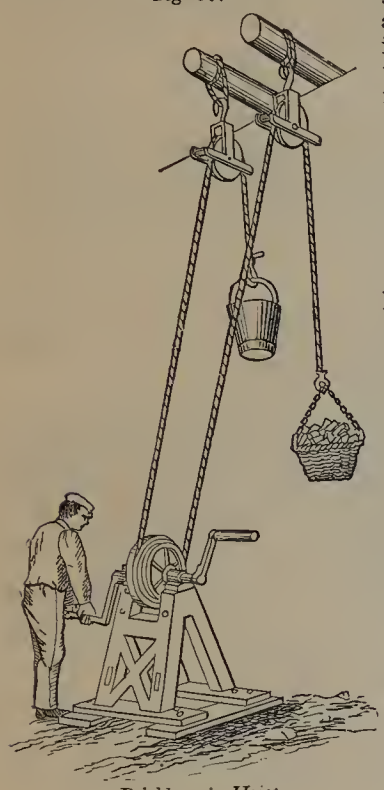


Brick-Kiln.

into burning brick-kilns for the purpose of distributing the heat from the hotter portions to parts where the heat is lesser. Other devices are for drawing air through a sectional kiln when the baking is completed, in order that a part of the accumulated heat may be employed in other sections of the compound kiln.

Brick'lay-er's Ham'mer. (*Bricklaying.*) A tool having a hammer-head and a sharpened peen, forming an axe for dressing bricks to shape.

Fig. 907.



Bricklayer's Hoist.

Brick'lay-er's Hoist. A winch and tackle for lifting bricks and mortar in building.

Brick'lay-ing. The implements of the bricklayer are a *trowel*, for spreading mortar and breaking bricks when a piece smaller than a whole brick is required; a *hammer*, for making openings in the brick-work and for driving or dividing brieks, for which purposes one end is formed like a common hammer, and the other is broad and flattened, somewhat after the manner of an axe; the *plumb-rule*, made generally of wood, having a longitudinal opening down its middle and a plummet suspended from its upper end, for carrying walls up perpendicularly; the *level*, consisting of a long horizontal arm, having a perpendicular branch carrying a vertical arm from which a plummet is suspended; a large *square*, for laying out the sides of a building at right angles; a *rod*, usually five or ten feet long, for measuring lengths; *compasses*, for traversing arches and vaults; a *line* and *line-pins*, for keeping the courses straight and level as the work progresses; and a *hod*, for carrying bricks and mortar to the workman.

Brieks are laid in courses so as to break joints, and their arrangement with regard to each other constitutes what is called the *bond*. There are two kinds of bond made use of in England and Ameriea, — *English* or *old English*, and *Flemish*, — the former, however, being mueh more commonly employed than the latter. See BOND.

See MASON'S and BRICKLAYER'S TOOLS, etc.

Brick-ma-chine'. Bricks have been made by machinery for many years. Some of the early United States patents, of which the record was unfortunately burned in 1836, are dated 1792, 1793, 1800, 1802, 1806, 1807, and a tolerably constant stream has followed them. About 122 patents were granted in the United States previous to June, 1836, for brick and tile machines, and more than 500 patents have since that time been granted for brick-machines. The number is rapidly increasing. In England, probably over half that number are on record for making brick.

It will be impossible in the space which can be devoted to that subject to do more than present a few examples of the different forms which have been brought forward. This will show the direction of invention in this line, and will suggest to the reader the various modes of forming a rectangular block of plastic clay. These are the terms of the problem. As usual, where important interests are at stake, the resolution has called a diversity of machines into existence.

Brick-machines are of several classes.

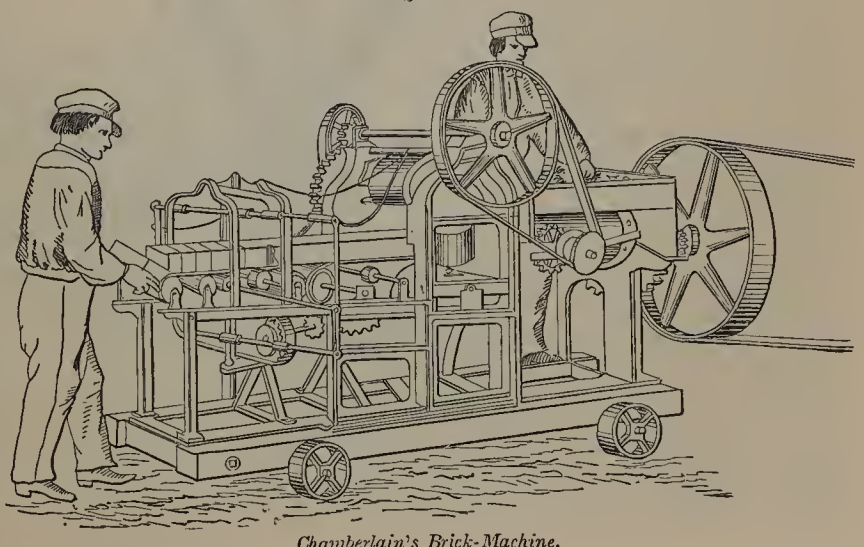
Class I. Those in which a slab of clay exudes from the pug-mill, and is cut up into lengths which form bricks. The cutter is a wire or knife, and either travels with the slab while cutting, or moves in an oblique path, so as to make a square transverse cut across the moving slab.

CHAMBERLAIN'S English machine is in prineiple as follows: —

The clay is fed into a pug-mill placed horizontally, which works and mixes it, and then forces it through a mouth-piece or die of about 65 square inches, or about half an inch deeper and half an inch longer than is required for the brick, of a form similar to a brick on edge, but with corners well rounded off, each corner forming a quarter of a 3-inch circle; for clay will pass smoothly through an aperture thus formed, but not past a sharp angle. After the clay has escaped from the mill, it is seized by four rollers covered with a porous fabric (moleskin), driven at a like surface-speed from connection with the pug-mill.

These rollers are two horizontal and two vertical ones, having a space of 45 inches between them. They take this larger stream of rough clay, and press or roll it into a squared block of the exact size and shape of a brick edgeways, with sharp edges, — for the clay has no friction, — being drawn through by

Fig. 908.



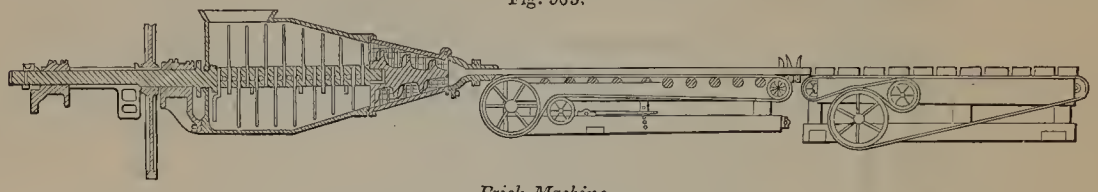
Chamberlain's Brick-Machine.

the rollers, instead of forcing itself through, and is delivered in one unbroken stream. The rollers in this machine perform the functions of the die in one class of machinery, and of the mold in the other. They are, in fact, a die with rotating surfaces. By hanging a series of mandrels or cores between these rollers, or by merely changing the mouth-piece, hollow and perforated bricks may be made without any alteration in the machinery. The slab is cut up into bricks by transversely-moving knives or wires.

In the brick-machine Fig. 909 the tempering-chamber, impelling-screw, and forming-die are in the same horizontal line, and of a conical shape, the forming-die being at the apex; the clay is received at the hopper on the cylindrical portion, worked by the beaters, and delivered to the screw which works at the end of the same shaft, and with a gradually increasing depth of thread terminates before it reaches the die, so as to make the clay leave in a solid mass; the walls of the screw-chamber are roughened to prevent the revolution of the clay.

The clay is delivered upon an endless apron, by which it is carried to a knife working by attachment to a fly-wheel, which, being controlled by the same power, makes its cuts at regular distances in the traversing mass of clay; the latter is supported at

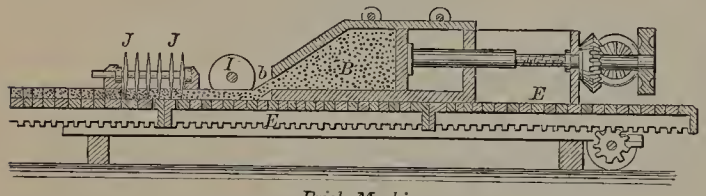
Fig. 909.



Brick-Machine.

the point of impact of the knife by a movable frame underneath, which moves with the knife, and the brick as it is cut off rests upon another apron, which, traversing faster than the former, soon makes an interval between the bricks.

Fig. 910.



Brick-Machine.

In Fig. 910 the clay is forced from the reservoir *B* by the piston, which is driven by a screw and bevel-gearing. It issues through a throat or die, whose opening admits a wide slab of clay *b*, to be subsequently cut up by two series of knives, which divide it longitudinally and transversely. *I* is one of the knives, of which there are several on the same shaft; they are distant apart the length of a brick, and divide the slab into ribbons longitudinally. *J J* are a series of knives which are placed on a mandrel whose bearings are in a carriage, and the latter moves in ways across the path of the slab of clay and cuts the ribbons into bricks, the knives *J* being distant apart the width of a brick. The bed is made in sections *E E*, which are passed in succession through the machine by means of the racks and pinion.

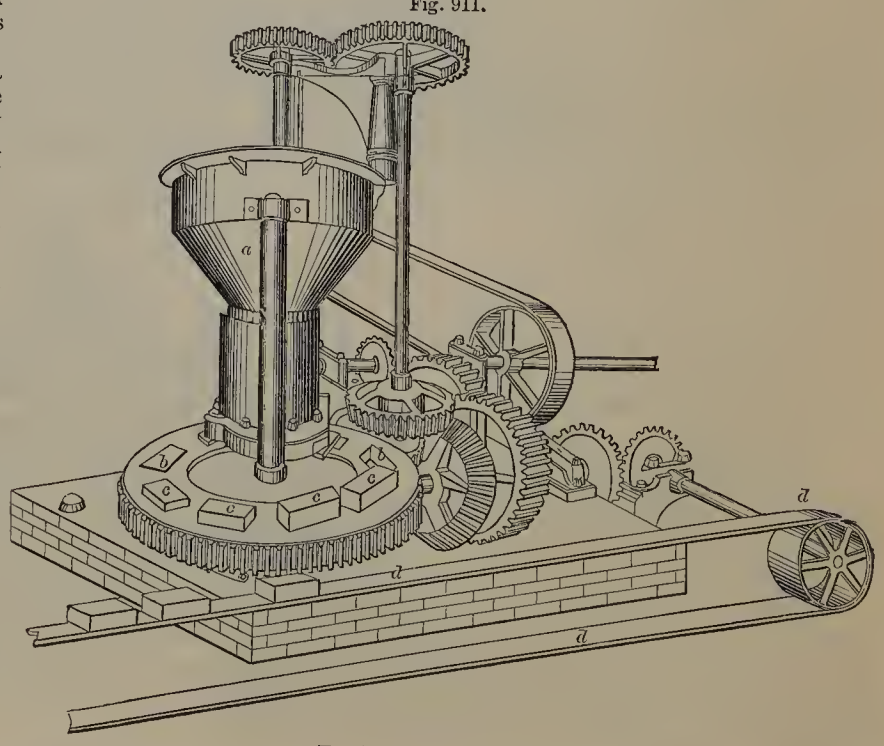
Class II. Those in which the clay passes from the pug-mill into molds, in which it is pressed, and from which the molded brick is discharged.

This class has six varieties: —

Var. 1: Those in which the molds are on the upper surface of a mold-wheel revolving in a horizontal plane, the molds being brought successively below the pug-mill, by which they are charged. The pressing and discharging devices vary in different machines.

Fig. 911 shows an English machine of this variety. It consists of a vertical pug-mill *a*, into the upper part of which the clay is fed. In this part of the apparatus the clay is tempered and mixed, and is thence forcibly pressed into the molds *b*, which are arranged in a circular revolving table. As this table revolves,

Fig. 911.



English Brick-Machine (from Ure).

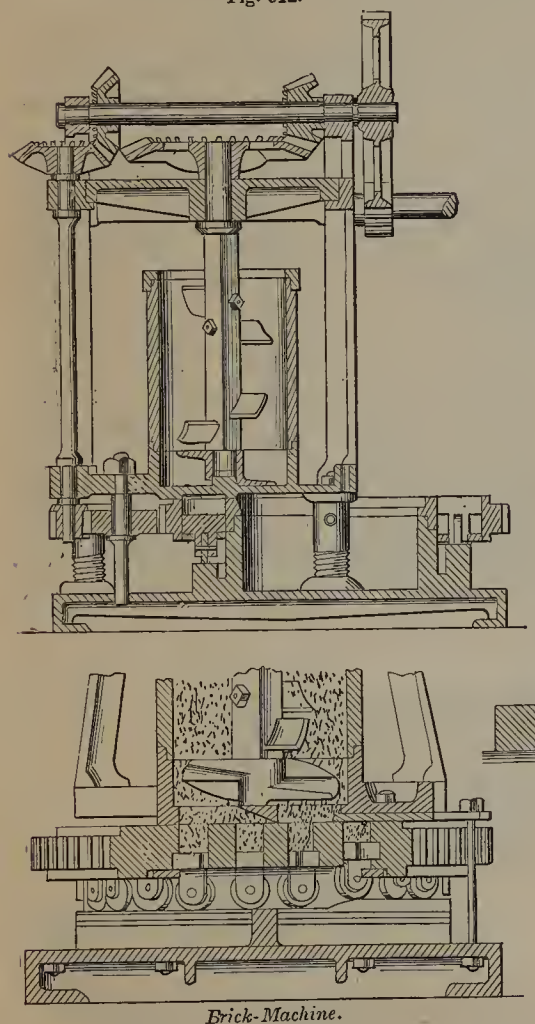
the pistons of the molds ascend an inclined plane, and gradually lift the bricks *c* out of the molds *b*, whence they are taken from the machine by a boy and placed on an endless band *d*, which carries the bricks direct to the hacker.

The speed of the several parts of the machine is so arranged that the operations of pugging, molding, and delivering proceed simultaneously in due order, the whole being driven by a steam-engine of about 6-horse power, which, at the ordinary rate of working, will make 12,000 bricks per day, or, with 8-horse power, from 15,000 to 18,000.

Fig. 912 is an American form of brick-machine, of the same class and variety as the last.

The pug-mill shaft has a series of oblique arms, and at the foot has a pressing spiral which forces the tempered clay into the molds of the horizontally rotating table beneath. As the wheel rotates, the rollers beneath the followers which form the mold-bottoms rise upon inclines, which lift the followers and discharge the brick from the mold.

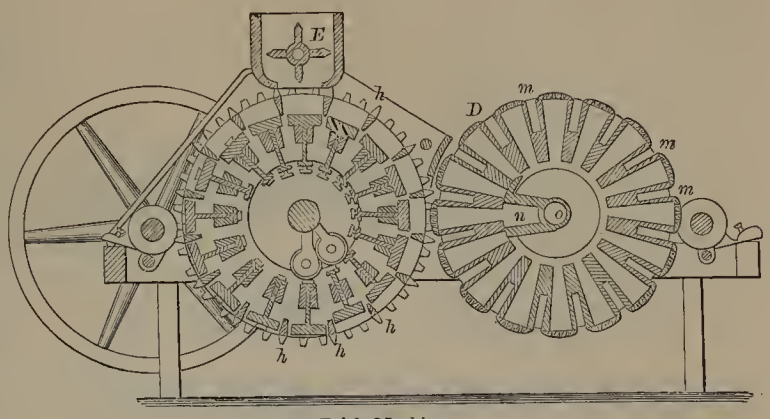
Fig. 912.



Brick-Machine.

Var. 2 : Those in which the molds are on the periphery of a wheel, and receive their charge from a pug-mill or hopper above. The clay in the mold is pressed by the application of exterior or interior force, or both, and the molded bricks are discharged by piston-followers ; in most cases operated by cams or toggles.

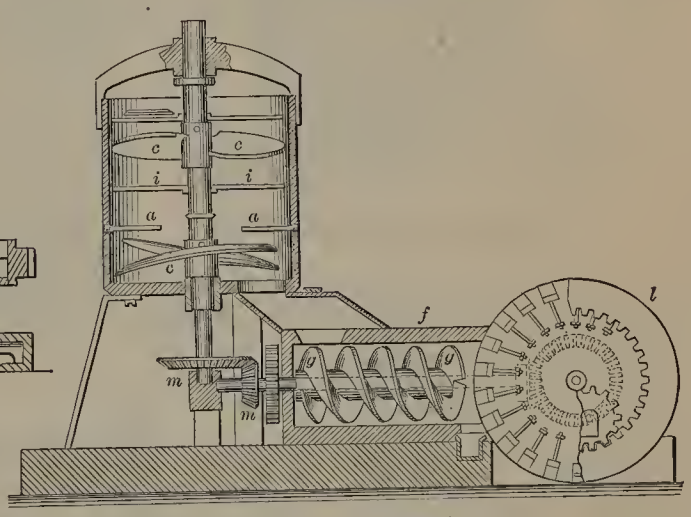
Fig. 913



Brick-Machine.

In the example (Fig. 913) the pulverized clay passes from the hopper *E* into the molds in the periphery of the wheel below. The clay is pressed in the molds by the perforated pressing surfaces of the opposite wheel *D*. As each of these pressing surfaces comes in contact with the clay, it is also brought in contact with the trunk *n* and pipe *o*, which lead to an air-pump. The air is thus exhausted from the clay while the latter is under pressure.

Fig. 914.



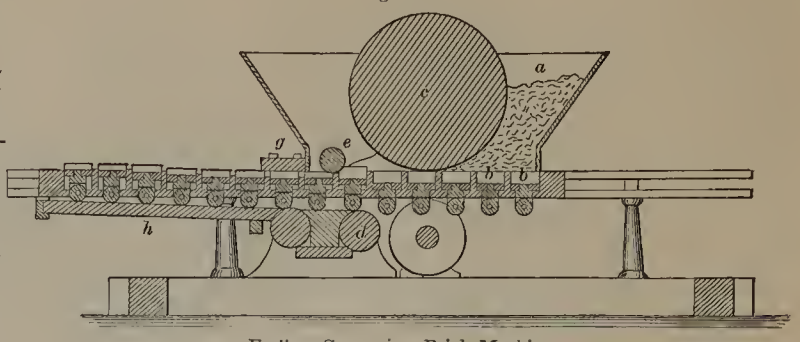
Brick-Machine.

The depressions *m* between the perforated pressure-surfaces of the wheel *D* receive superfluous clay, and also receive the teeth *h* of the mold-wheel, and thus insure the accurate meeting of the molds and pressers.

The machine (Fig. 914) has an upright hollow cylinder, through which passes a vertical shaft. To this shaft there are secured spiral flanges *c* and knives *i*, the latter being attached to the shaft horizontally in pairs. To the inner side of the cylinder there are secured horizontal knives *a*, having a radial position. Below the upright cylinder is a box *f*, in which is placed a horizontal screw *g*, which conveys the clay to the molds, the shaft of the said screw being connected to the vertical shaft by bevel-gears *m*. In the rear end of the box which contains the screw is mounted

a wheel *I*, having its periphery perforated with rectangular openings which form the brick-molds, each mold being provided with a piston or plunger. In the lower part of the box, and just in the rear of the wheel, is fitted transversely a box which serves as a scraper to take the superfluous clay from the periphery of the wheel, and to smooth and compact the clay at the surfaces of the molds. As the latter come to their lowest position, the followers are moved and eject the bricks.

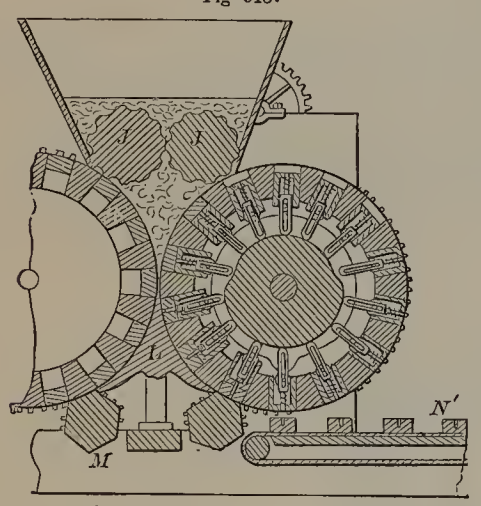
Fig. 916.



Endless Succession Brick-Machine.

Var. 3 : Those in which two wheels are provided with peripheral molds which are charged with clay from a hopper above, and in which the pressure is derived in whole or in part from the contact of the peripheries of the wheels with each other. Of this variety and class is Fig. 915. The corrugated feed-roll-

Fig 915.



Double-Cylinder Brick-Machine.

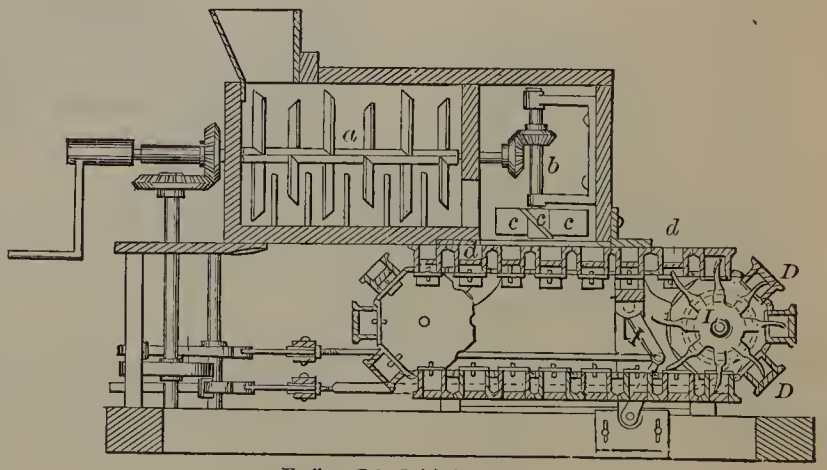
ers *J J'* in the hopper drive down the clay, which enters the molds in the peripheries of the contacting cylinders. On the faces of the said cylinders are alternate molds and spaces, the latter forming pressure-surfaces for the clay in the molds of the opposite cylinder. The cylinders are counterparts of each other and are coöperative, being geared together so as to run in exact correspondence. Each mold has its piston or follower, which is moved radially by contact with a cam on the main-shaft of its cylinder. As soon as the mold passes the edge of the dividing block, the cam commences to thrust out the follower and reduce the brick to a smaller compass, pressing it against the face of a roller. This gives the outer face of the brick a concave form, but it is presently brought against one of the facets of the hexagonal roller *M*, which is so geared as to present its surface to the openings of the mold in a given cylinder in succession. When the mold reaches the lowest position in its revolution, the follower is farther advanced and discharges the molded brick on to the off-bearing apron *N'*. This description of the action in one mold is true of each mold in each of the cylinders. By way of giving farther compression, spring-plungers are advanced, after passing the divider *L*, and make a perforation in the brick which is retained, as the plunger is not retracted until after the brick has passed the last point of pressure.

Var. 4 : Machines in which a series of molds are linked together to form an endless series, or are placed on an endless belt or track, and are passed beneath the charger, from whence they pass to the presser.

Fig. 916 is an illustration of this variety. The clay passes from the hopper *a* into the molds *b b*, and is pressed thereinto as they run beneath the pressure-roller *c*. The follower at the bottom of each mold is raised by the contact of its carriage with the roller *d* beneath the track. The effect is to partially remove the brick from its mold and expose it to the pressure of a second roller *e*. It then passes under a smoothing-block *g*, after which the follower-carriage climbs an inclined plane *h*, which elevates the brick from the mold. The molds are contained in a sliding frame which runs beneath the pug-mill, and, after discharging the bricks, returns empty to commence a new stroke.

In Fig. 917 the molds, in an endless chain, hinged together and running over two sprocket-wheels, are provided with movable bottoms, which are acted upon to press the contents of the mold, and also to

Fig. 917.



Endless Belt Brick-Machine.

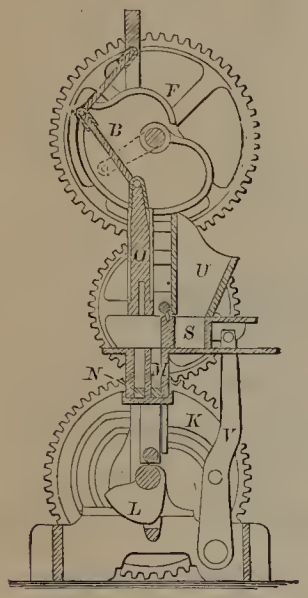
force the brick out of the mold at the proper time. *a* is the pug-mill, and *b* the chamber from which the clay is ejected by the oblique arms *c*, being received

into molds in the boxes *D* as they pass in turn beneath the throat in the bottom of chamber *b*. As the mold passes this point, it receives pressure from the intermittingly operating plunger attached to the toggle *I*, and shortly after the mold-bottom *d* is lifted by a spoke of the discharging-wheel *L*, which ejects the brick.

Var. 5 : Machines in which the clay is molded by the force of a reciprocating piston or pistons.

The operation of the machine (Fig. 918) is as follows : The clay passes from the hopper *U* into box

Fig. 918.



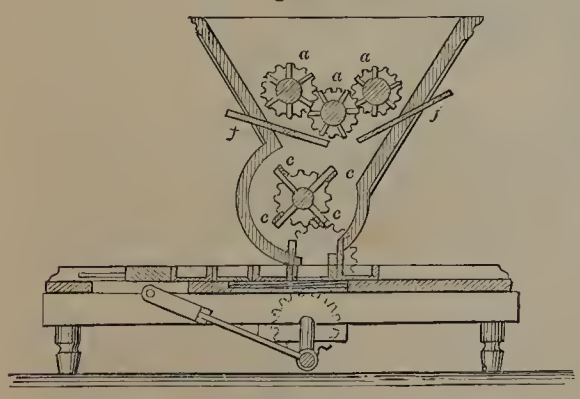
Piston Brick-Press.

S; the latter is then moved by the cam *K* and the intermediate arm *V*, shifting the charge of clay over the mold *M*, into which it drops. The box *S* then retires, and the plunger *O* descends, being driven by toggle *B*, and compresses the clay in mold *M*. The cam *F*, which regulates the motion of the said plunger, then causes the plunger *O* to rise, and cam *L* raises the plunger *N*, which removes the brick from the mold, to be swept from the table by the next forward movement of the box *S*.

Var. 6 : Machines in which the molds are reciprocated beneath the pug-mill.

In Fig. 919 the clay is mixed and forced out of the hopper by the revolving spiked wheels *a*, and passes between the plates *f f*, whose distance regu-

Fig. 919.



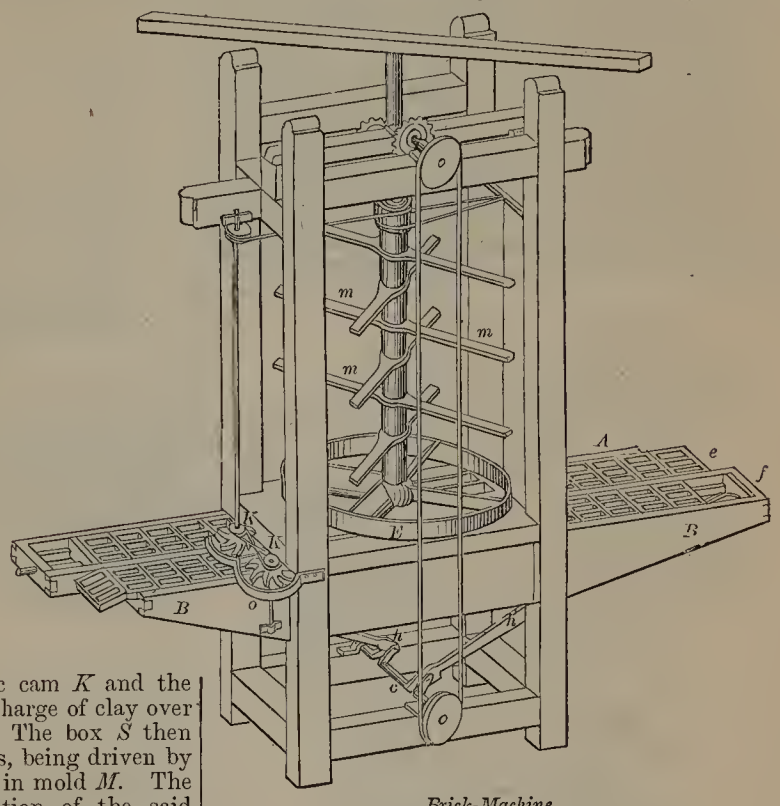
Brick-Machine.

lates the rate of passage of the clay. The beaters *c c* drive the clay into the molds beneath, which are intermittingly advanced by a sliding-block, which is reciprocated by a pitman and crank deriving their motion from the shaft below.

In Fig. 920 the casing-cylinder of the pug-mill is removed, to expose the blades *m m* to view.

Motion being given to the shaft *c*, the cranks and pitmans *h* and *h'* operate the shoving-boards *e* and *f*, on which the molds are placed ; the molds are thus moved on the two tables *A* and *B* in an opposite di-

Fig 920.



Brick-Machine.

rection, and at each revolution of the shaft *c* one row of molds on one table is filled with clay from the hopper, while on the other table an empty mold can be replaced behind the shoving-boards *e* and *f;* thus an operator, standing at the end of the tables *A* and *B*, can replace the empty molds on one table and withdraw the filled molds from the other table at the same time.

The blades on the shaft in the pug-mill mix and depress the clay, which passes through holes in the floor corresponding to the position of the molds, which are passed below by the intermittent motion described. The wheel *E* has blades which scrape the clay from the pug-mill floor. The supplementary scrapers *K K*, and curved guard *o*, remove the superfluous clay from the molds. The latter are removed by the off-bearers, and the contents dumped upon the floor of the drying-ground.

Class III. Those in which clay in a nearly dry state is compressed by a plunger into a mold, from which it is discharged after receiving a pressure, which causes the remaining moisture to form a bond of cohesion between the particles.

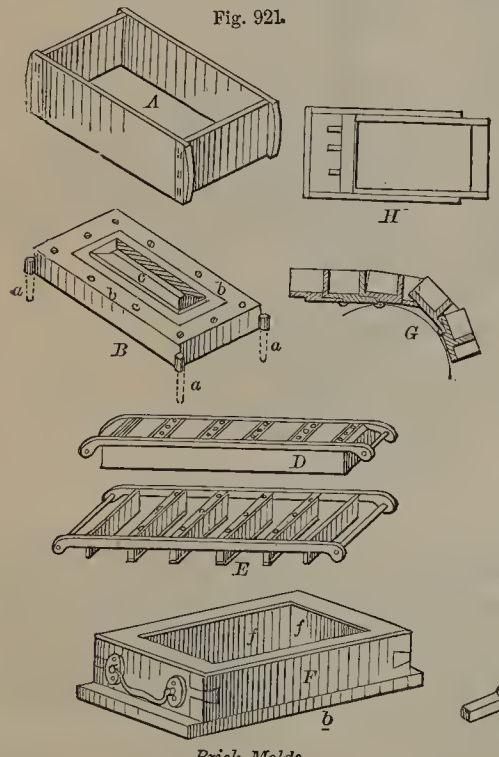
The functions of these machines refer to means for extreme pressure and the extraction of the air which accompanies the crumbly material into the mold. In other respects the machines of this class are some-

what like the piston-machines of Class II., Var. 5. For this purpose an adaptation of the hydraulic press is especially applicable and is in use. Bricks are also made of dried and pulverized clay, mixed with a due proportion of sand and perhaps lime, and molded under hydraulic pressure.

Brick-mold. A box in which clay for bricks is molded into shape. The adobes of the Orient, ancient and modern, and of the Western plains, are made by filling with clay a four-sided box, pressing it down compactly, and cutting off the superfluous clay evenly with the edge of the box. The box is usually destitute of top and bottom, lies upon a board while being filled, and, when lifted, leaves the brick in position to dry.

Brick-molds may be lined with iron or brass from which the molded brick slips more readily than it does from wood. The sand in the clay wears away the surface very fast, especially when lined with brass. It is sometimes made of sheet-iron in four pieces, riveted together at the angles, and strengthened with wood at the sides only. The bottom of the mold is detached, and forms what is called the *stock-board b*. The latter is a piece of wood plated with iron round the outer edge, and made to fit the mold accurately but easily. At each corner an iron pin *a* is driven into the molding-table, and on these pins the bottom of the mold rests, the thickness of the brick being regulated by the distance to which the pins are driven below the top of the stock-board.

Fig. 921.



Brick-Molds.

In England, the surface of the brick which is to form the *bed*, that is, the bottom, has a depression to hold a mass of mortar. To make this is the purpose of the piece *c*, which projects above the general surface of the stock-board *b*.

A B are the corresponding parts of an ordinary mold, the upper four-sided portion *A* resting upon the lower portion *B* while being filled. *E* is a frame containing a number of division boards intended to be slipped into box *D*, to mold five bricks at once. The frame and box, being lifted, leave the bricks upon the ground to dry. *F* is a mold of wood lined with glass *f*.

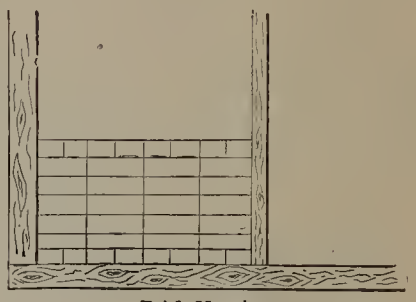
G represents part of a chain of molds as found in some kinds of brick-machines.

H is a mold which has an advancing piston with three punches designed to make openings into the brick for the more ready exit of the air. Used in *re-pressing* brick-machines, which gave a great pressure at a second operation, or act with a great pressure upon prepared clay, which is apparently dry.

Brick-nog'ging. (*Building.*) Called also *brick and stud* work.

A *brick-nogging* wall or partition is one in which

Fig. 922.



Brick-Nogging.

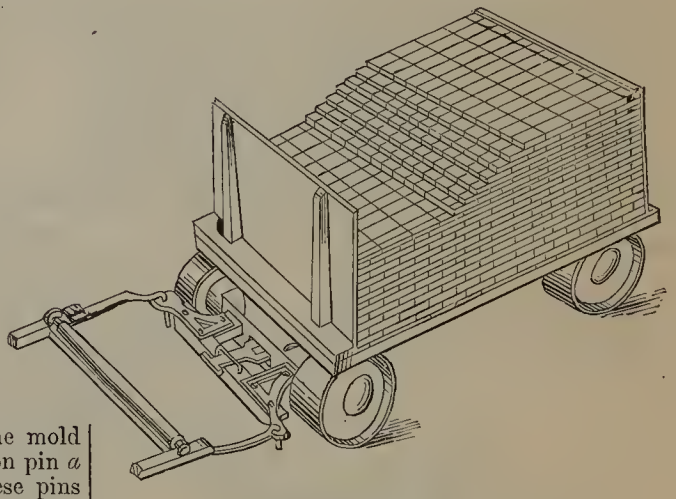
the spaces between the timbers or scantling are filled up with brick laid in mortar. In a brick-nogging partition the wooden portions are called *nogging-pieces*.

Brick-press. See BRICK-MACHINE.

Brick-trim'mer. (*Building.*) A brick arch abutting upon the wooden trimmer under the slab of a fireplace, to guard against the communication of fire.

Brick-truck. One with wide tires to travel over

Fig. 923.



Brick-Truck.

the flat surface of the brick-yard in moving brick from the hack to the kiln.

Brick-work. (*Bricklaying.*) The English regulation brick is $8\frac{1}{2} \times 4 \times 2\frac{1}{2}$ inches. Of such, —

One foot of brick-work ($1\frac{1}{2}$ bricks thick) contains 17 bricks.

One foot superficial of Flemish bond requires 8 bricks.

One cubic foot comprises 125 bricks, or 95 pounds of sand, or 135 pounds of clay, or 126 pounds of common earth.

One great ton weight (2,240 pounds) comprises

330 bricks, or 23½ cubic feet of sand, or 17⅓ of clay, or 18 of earth.

One cubic foot of brick-work weighs 120 pounds; 1 rod of fresh brick-work (11¼ cubic yards) weighs 35,840 pounds.

Bridge. 1. (*Engineering.*) A structure erected over a water-way, ravine, or road, for the transit of persons, animals, or vehicles. A *viaduct.*

The only reference to a bridge in the canonical Scriptures is an indirect one, in a name referring to the "bridge of the sons of Jacob." It is at a place northeast of the Sea of Galilee, and a bridge still exists at the place.

The bridge erected by Nitocris, across the Euphrates at Babylon, consisted of stone piers supporting a series of wooden platforms, which were capable of being withdrawn, to prevent passage at night between the portion of the city on the respective sides of the river. (Herodotus, I. 186.)

The "huge stones cramped together by iron bars and melted lead" were probably in the piers. We may surmise that the foundations of these were laid while the river was temporarily diverted, or made in an artificial channel to which the river was subsequently transferred. Either plan was possible in that country, and the former was tried, to the cost of the Babylonians, by Cyrus, many centuries after Nitocris.

Ancient bridges of great magnitude exist in China. This ingenious people constructed them of wood, stone, chains, and ropes, before history commenced to be written in Europe. The great wall of China (*Wan-li-chang*, the myriad-mile-wall) was finished about 220 B. C., and has many stone bridges over the various streams which it crosses in its course of 1,250 miles. It puts into the shade the British wall of Agricola, which united the Tyne and the Solway, 80 miles; and the other Roman wall which united the Forth and Clyde, 36 miles.

The Egyptians built no permanent bridges across the Nile, but were familiar with framing trestle-work, and with ponton and draw bridges; the latter are seen frequently in their paintings representing fortified towns, sieges, etc.

The Greeks had but small rivers, and had no stone bridges until after the Roman conquest.

We learn from the Greek historians that bridges were constructed by Cyrus (536 B. C.), Darius (490 B. C.), Xerxes (480 B. C.), and Pyrrhus (280 B. C.). Each of these was a military bridge for a special purpose, and had no permanent character. The bridge of Cyrus, over the Meander, was supported on boats, like those which crossed the Bosphorus and the Hellespont under the orders of his successors; Xenophon states that the bridge of Cyrus had seven boats.

The bridge of Xerxes was 500 paces in length. Ships were used as pontons; cords of flax and biblos united them; transverse beams were laid on the ropes; planks on the beams; soil on the planks; and the armies crossed thereon. Cords and posts at the sides afforded some degree of protection.

How many bridges were built by Pyrrhus in his expeditions, history does not inform us; but the bridges in his Italian campaigns, about 280 B. C., over the streams emptying into the Adriatic, are mentioned by the Greek historians.

The first bridge in Rome was built across the Tiber, 621 B. C., by Ancus Martius, uniting the Janiculum and Mons Aventinus, and was memorable for its defence by Horatius Cocles against Lars Porsenna the Etruscan, about 508 B. C.; also as the spot whence the body of Heliogabalus was cast into the Tiber, a stone about his neck, about A. D. 218. It was called the Pons Sublicius, from its having been built upon stakes, or piles. The original bridge was built about the time of Josiah, king of Judah, and a few years previous to Nebuchadnezzar.

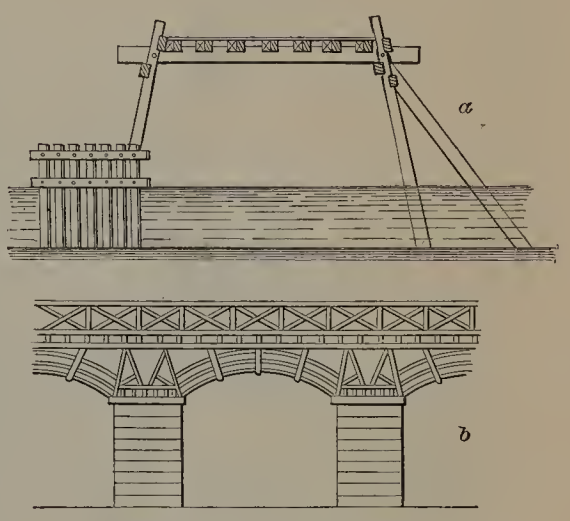
The Pontus Salarius was erected by Tarquinius Priscus, about 600 B. C. It spanned the Teverone, and is believed to have had three arches of stone. Doubts have been suggested as to the authenticity of this account; but it is not surprising when we consider the *Cloaca Maxima*, constructed in the same reign.

The Romans appear to have been the first to construct arched bridges; several of which still exist in Syria and Palestine, and are the oldest stone-arch bridges in existence, unless some of the Etruscan and Chinese bridges antedate them.

The Pons Senatorius was erected across the Tiber by Caius Flavius Scipio, 127 B. C.

A trestle-bridge on piles (*a*, Fig. 924) was built by Julius Cæsar across the Rhine about 55 B. C. He left an account of its construction, but the authorities construct it differently from the specification extant. It was founded upon piles driven into the bed of the river. The piles were united by a beam, on which were laid joists in the direction of the length of the bridge. Upon the joists were laid hurdles supporting the road-bed. An inclined fender protected the piers up stream, and each pier was stayed below by a cluster of piles. It was built in ten days.

Fig. 924.



Julius Cæsar's and Trajan's Bridges.

A magnificent bridge with four stone arches was built by Augustus near Narni, on the road from Rome to Loretto. The arches were respectively 75, 135, 114, and 142 feet span. One arch remains.

The bridge of Trajan (*b*, Fig. 924), which crossed the Danube, was one of the greatest engineering works of antiquity. It was constructed of timber resting upon stone piers. Each span consisted of three rows of concentric arches, united by binding-pieces formed upon each division; these abutted upon timbers radiating with the curve, which were framed into heads and sills, again strengthened by braces and struts; the joists which carried the floor traversed the bridge, and rested upon strong plates laid upon the timber arches.

Apollodorus was the architect, A. D. 105. The bridge was 4,770 feet long. The foundation was made by sinking large barges filled with stones, lime, and sand, and filling in the interstices with

bags of similar material. On these the piers were built. The bridge had 20 semicircular arches of 180 feet 5 inches span. Their springings were 46 feet above the general level of the river. The piers were 150 feet high above their foundations, 64 feet thick, 85 feet 3 inches wide. The bridge was 60 feet wide.

It was destroyed by Hadrian, the successor of Trajan, to prevent the incursions of the barbarians. Rome was then beginning to assume the defensive.

Among the other Roman bridges which yet remain, whole or in part, to testify to the skill of the engineers and extort our admiration, are those of Merida and Alcantara, in Spain. The former is over the Guadiana, 3,900 feet long, and has 64 arches. The latter is over the Tagus, 670 Spanish feet long, 6 arches; road-bed 205 feet above the river.

The bridges of London are celebrated in history, especially that portion of history in which we who speak English are most interested. A wooden bridge existed over the Thames in A. D. 978. One was built of wood in 1014; one by Peter of Colechurch, 1176–1200, with houses on each side connected by arches of timber which crossed the street. This was burned in July, 1212, and 3,000 persons perished. The buildings being on fire at the Surry end, a great crowd rushed to see the fire, and the wind blew the burning shingles to the north end, lighting the buildings at the Middlesex side of the river. Between fire and water the loss of life was dreadful. The bridge was restored in 1300; again partially burned in 1471, 1632, and 1725. The houses were pulled down in 1756. At what time stone arches were substituted for wooden spans does not appear. When the present London bridge was built in 1831, the elm piles of the old bridge were yet sound, after 600 years' use.

In the twelfth and thirteenth centuries A. D. a very useful society flourished in Europe, called the "Brothers of the Bridge." The building of bridges was at that time deemed an act of piety, and we must highly respect that devotion which, in the fear of God, finds its expression in deeds of exalted usefulness.

Benezet built a bridge at Avignon over the Rhone, which was finished in 1188. It had 18 stone arches, and was 3,000 feet long. The arch which supported the chapel dedicated to St. Nicholas, the patron of sailors and those whose business is upon the waters, remained long after the other arches had been swept away by the storms of centuries. Benezet's tomb was in the crypt.

About 1300, Issim, the Moorish king of Granada, erected a fine bridge at Cordova, across the Guadalquiver.

Perronet mentions a stone bridge of three arches, one of which had a span of 159 feet 9 inches, at Verona, erected in 1354. Also a bridge with a stone arch 183.8 feet span, 70.6 feet rise, erected 1454, at Vielle Bronde, over the Altier, by Grennier.

The Rialto, of Venice, was erected by Antonio del Ponte, 1588. It has a span of 98½ feet.

The art of bridge-building, which was understood by the Romans, fell into disuse when that political system became disintegrated. When the arts revived, the Italians took the lead.

Much has been done of late years, and the designs become more and more bold. London Bridge, Menai Tubular Bridge, the St. Lawrence Bridge at Montreal, the Cincinnati Bridge, Southwark Bridge, London, the Cabin John Creek Bridge, Maryland, and the Schuylkill Bridge at Philadelphia, are trophies of their kind. The suspension bridge across the East River, New York (see Frontispiece), is by far the boldest undertaking in the suspension line, nearly 600 feet greater than the now widest span, — the bridge at Cincinnati. The steel tubular-arch bridge at St. Louis is to cross the Mississippi in three spans, which have only one rival among arches, — a single-span bridge in Holland.

The highest bridge in the world is the Verrugas Viaduct on the Lima and Oroya Railroad, in the Andes of Peru. It crosses a mountain-torrent called the Agua de Verrugas, in a wild and picturesque locality 12,000 feet above the level of the sea. The structure consists of four deck-spans, or trusses, three of which are 110 feet long, and one, the central span, 125 feet long. The spans rest on piers built of wrought-iron columns. The piers are 50 feet long by 15 feet wide on top. There being three piers, the total length of the viaduct is 575 feet. The piers are respectively 145 feet, 252 feet, and 187 feet high. Each pier consists of 12 legs, which in plan form a rectangle. The legs are composed of a series of wrought-iron six-segment columns, in lengths of 25 feet, connections being made by cast-iron joint-boxes having tenons on each end running into the column. The columns have an exterior diameter, including flanges, of 16 inches.

The mountain-chain will be crossed at an altitude of 15,000 feet by a tunnel 3,000 feet in length. The grades are the steepest known on any ordinary railway. The workmen employed are Cholos Indians, the only operatives who can endure for a prolonged period the rarified atmosphere at this great elevation.

The subject, after this slight historical general sketch, will be considered under the headings which naturally suggest themselves, founded upon the differences in material, construction, and purpose.

See under their respective heads: —

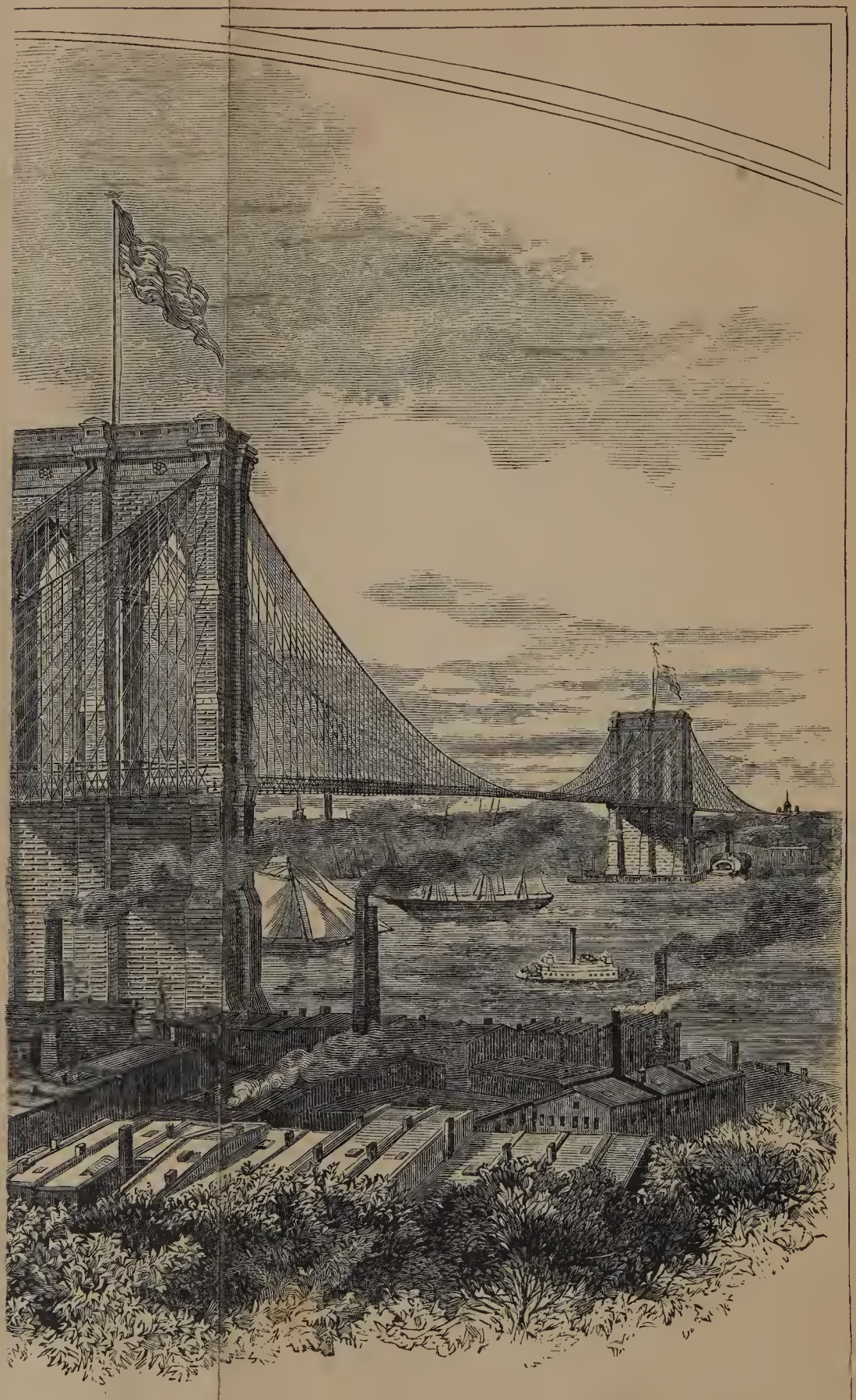
Arched-beam bridge.
Balance-bridge.
Baseule-bridge.
Boat-bridge.
Bowstring-bridge.
Bridge-equipage.
Bridge-stone.
Bridge-train.
Cable-suspension bridge.
Canal-bridge.
Carriage-bridge.
Chain-bridge.
Cheek-bridge.
Chinka-bridge.
Counterpoise-bridge.
Drawbridge.
Electric bridge.
Ferry-bridge.
Fire-bridge.
Flame-bridge.
Floating-bridge.
Flying-bridge.
Foot-bridge.
Furnace-bridge.
Girder-bridge.
Half-lattice girder.
Hoist-bridge.
Hose-bridge.
Iron bridge.
Iron-arch bridge.
Lattice-bridge.
Leaf-bridge.
Lifting-bridge.
Military-bridge.
Millstone-bridge
Pile-bridge.
Pivot-bridge.
Platform-bridge.
Ponton-bridge.
Raft-bridge.
Rolling-bridge.
Rope-bridge.
Skew-bridge.
Steel-bridge.
Stiffening-girder.
Stone-bridge.
Suspension-bridge.
Swing-bridge.
Swivel-bridge.
Tension-bridge.
Trainway for ferry-boats.
Trestle-bridge.
Truss-bridge.
Tubular-bridge.
Tubular-arch bridge.
Turn-bridge.
Viaduct.
Weigh-bridge.
Wooden bridge.

2. (*Steam.*) *a.* A lower vertical partition at the back of the grate-space of a furnace. The flame in passing the bridge is deflected upward against the bottom of the boiler.

Bridges are of metal or fire-brick. They may be hollow and form a part of the water-space of the boiler. Such are called *water-bridges.*

PLATE II.

SUSPENSION BR
(*Building.*)
BETWEEN BROOKLYN AND N



IDGE.

W YORK CITY.

See *Suspension Bridge.*

When a hollow water-bridge depends from the bottom of the boiler of which it forms a part, it is called a *hanging bridge*.

A bridge in the mid-space, with flue-space above and below it, is a *mid-feather*.

b. "The middle part of the fire-bars in a marine boiler, on either side of which the fires are banked." — ADMIRAL SMYTH.

3. (*Shipbuilding.*) A partial deck extending from side to side of a vessel amidships. It is common in steam-vessels, affording a convenient station for the officer in command, and extends over the space between the paddle-boxes. It is also known in England as the *hurricane*-deck or *bridge*-deck.

4. *a.* (*Metallurgy.*) The low wall of division between the fuel-chamber and hearth of a REVERBERATORY FURNACE (which see).

b. (*Puddling.*) The wall at the end of the hearth towards the stack, compelling the caloric current to ascend and then descend towards the foot of the stack.

5. (*Music.*) A bar placed beneath the strings of a musical instrument to elevate them above the sounding-board.

6. (*Ordnance.*) The pieces of timber between the transoms of a gun-carriage. (English.)

7. (*Horology.*) A piece raised in the middle and fastened at both ends to the watch-plate, and forming a bearing for one or more pivots.

When supported at one end, it is a *cock*.

8. (*Engraving.*) A board resting on end-cleats, used by an engraver to span the plate on which he is working, to support the hand clear of the plate.

9. (*Mining.*) The platform or staging by which ore, limestone, fuel, etc., are conveyed to the mouth of a smelting-furnace.

10. (*Electricity.*) A device used for measuring the resistance of an element of an electric circuit. See ELECTRIC BRIDGE.

Bridge-board. (*Carpentry.*) A notched board to which the *treads* and *risers* of a stair are fastened. A *notch-board*.

Bridge-eq'ui-page. The United States bridge-equipage is composed of two distinct trains, — the reserve and the advance-guard trains. The former is intended to accompany large bodies of troops in the field, and is provided with the material for the construction of bridges of sufficient capacity to pass large armies with their heaviest trains over rivers of any size and capacity. For these the French ponton is adapted.

The advance-guard train is intended for the use of light troops, such as advance-guards, cavalry expeditions, etc. It is organized, both as regards material and carriages, with a view to rapidity of movement. At the same time, it is capable of furnishing a bridge which will fulfill all the requirements of troops engaged on such service. For this train the canvas ponton is adapted. See PONTON-BRIDGE.

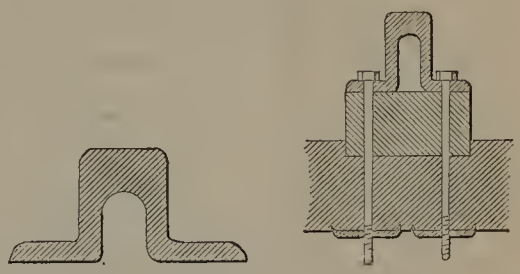
Bridge-head. (*Fortification.*) A work commanding the extremity of bridge nearest to the enemy; a *tête de pont*.

Bridge-o'ver. (*Carpentry.*) A term showing that certain parts lie across and rest on others; as, common joists, bridge-over binding-joists, etc.

Bridge-pile. (*Civil Engineering.*) A pile driven to support a timber of a bridge.

Bridge-rail. (*Railroading.*) A railroad-rail having an arched tread and lateral foot flanges. It was adopted by Brunel for the Great Western Railway

Fig. 925.



Bridge-Rail.

of England, which is excelled by none in the solidity of its track and bed. It is laid on a longitudinal sleeper in cross-ties. Felt saturated in pitch, or its equivalent, is placed beneath the rail over the sleeper, and gives a certain resiliency to the track.

The other rails are known as EDGE-RAILS and FOOT-RAILS (which see).

Bridge-stone. (*Masonry.*) A stone laid from the pavement to the entrance-door of a house, spanning a sunken area.

(*Road-making.*) A flat stone serving as a bridge across a gutter or narrow area.

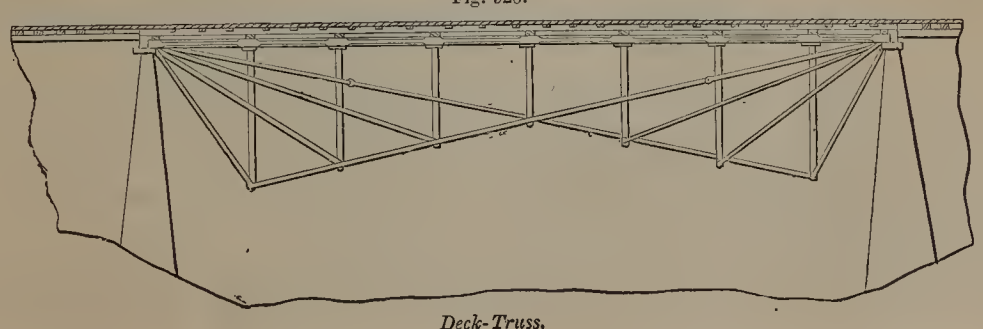
Bridge-train. A *bridge-equipment* or *ponton-train*, consisting of a military bridge composed of portable boats. See BRIDGE-EQUIPAGE; PONTON-BRIDGE.

Bridge-tree. (*Milling.*) The beam which supports the *spindle* of the *runner* in a grinding-mill. On the upper surface of the *bridge-tree* is the socket of the spindle. The bridge-tree is capable of vertical adjustment, to vary the relative distance of the grinding-surfaces, by moving the runner towards or from the bed-stone. The adjusting device is called a *lighter-screw*. See GRINDING-MILL.

Bridge-truss. A structure of thrust and tension pieces, forming a skeleton beam, in a viaduct. It has several varieties: the lattice, the arched truss, or combination of arch and truss, the deck-truss, in which the road-bed is on the straight stringers. See WOODEN BRIDGE; IRON BRIDGE.

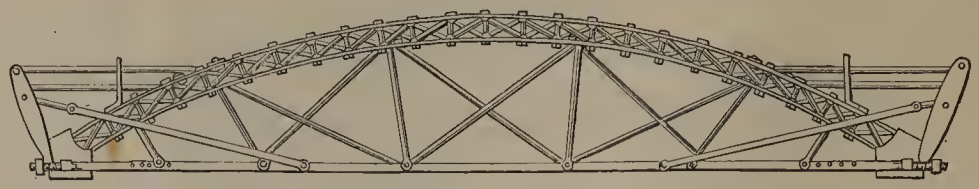
Fig. 926 shows a deck-truss in which the railway-track is laid upon the straining-beams, which are supported by posts and braces which act as tension-bars.

Fig. 926.



Deck-Truss.

Fig. 927.



Bridge-Truss.

Fig. 927 shows a trussed arch *B*, whose ends rest on skewbacks or shoes *G*. *A* represents one of the chords. *I I* are tension-straps, which act as suspension-chains to the chords, having their bearings on levers stepped in the shoes and braced against the truss by struts *N*.

Bridge-ward. (*Locksmithing.*) The main ward of a key; usually in the plane of rotation. See KEY.

Bridg'ing. (*Carpentry.*) Short cross-pieces connecting adjacent floor-joists to prevent lateral deflection. See CHIMNEY.

Single bridging has one pair of diagonal braces at the midlength of the joists. *Double bridging* consists of two pairs of cross-braces, dividing the joist into three lengths.

Bridg'ing-floor. (*Carpentry.*) A floor in which bridging-joists are used without girders.

Bridg'ing-joist. (*Building.*) A *joist* in a double floor, resting upon the *binder* or *binding-joist*, and supporting the floor. A *floor-joist*.

Bridg'ing-piece. (*Carpentry.*) A strut-piece nailed between joists or beams, to prevent lateral deflection. A *strutting* or *straining piece*.

Bri'dle. 1. (*Saddlery.*) A head-stall, bit, and bearing or riding rein, completing the head-gear of a horse's harness.

Bridles have differed in form, material, and caparisons in different nations and times, from the simple thong of the Indian to the rather preposterous bridle of the Japanese, as seen in the United States Patent Office collection. The sculptures disentombed by Layard, and the Egyptian paintings and carvings,

Fig. 928.

Assyrian Bridle (from Sculpture at Nineveh).

show patterns for the chase, for war, and for display. Except for a limited time the Jews had but few horses. This animal in those days was for show or for warfare, and the ox and ass divided the drudgery. The use and application of the bridle are, however, frequently mentioned in Scripture.

The primitive bridle was a noose around the lower jaw of the horse. In the most ancient paintings of Egypt, we find the head-equipments of the horses in full order, the bridles and bits complete.

David refers to the bit and bridle as the means of governing the horse and the ass, and Job refers to the bridle. Solomon bought his horses in Egypt, contrary to the express command of the law. He paid about $75 apiece (150 shekels). But the precious metals were relatively higher than now, in proportion to food and other necessaries.

The old Grecian bridle had somewhat similar leathers to our own. The bit was in several jointed portions. A breaking-bit for intractable horses was armed with prongs (*lupatum*, wolves' teeth).

Homer refers to the bridle and bit. Xenophon speaks of their uses and management. The last-mentioned writer refers also to the double-bridle, — a smooth snaffle-bit and a cruel spiked bit.

The Japanese bridle has a network of strings to defend the eyes from flies. The reins are of silk. The horse is usually led by a man holding the bridle near the bit, as the bridle-reins are held by grooms on each side, leaving the rider's hands free to hold on by the pummel.

The modern *bridle* of Europe and America consists of the following pieces: —

The *crown-piece*.	*Throat-latch* or *lash*.
Brow-band.	*Rein*.
Cheek-strap.	*Bit*.

Sometimes: —

Nose-band.	*Hitching-strap*.

Fig. 929 illustrates a number of bridles having checking or safety devices.

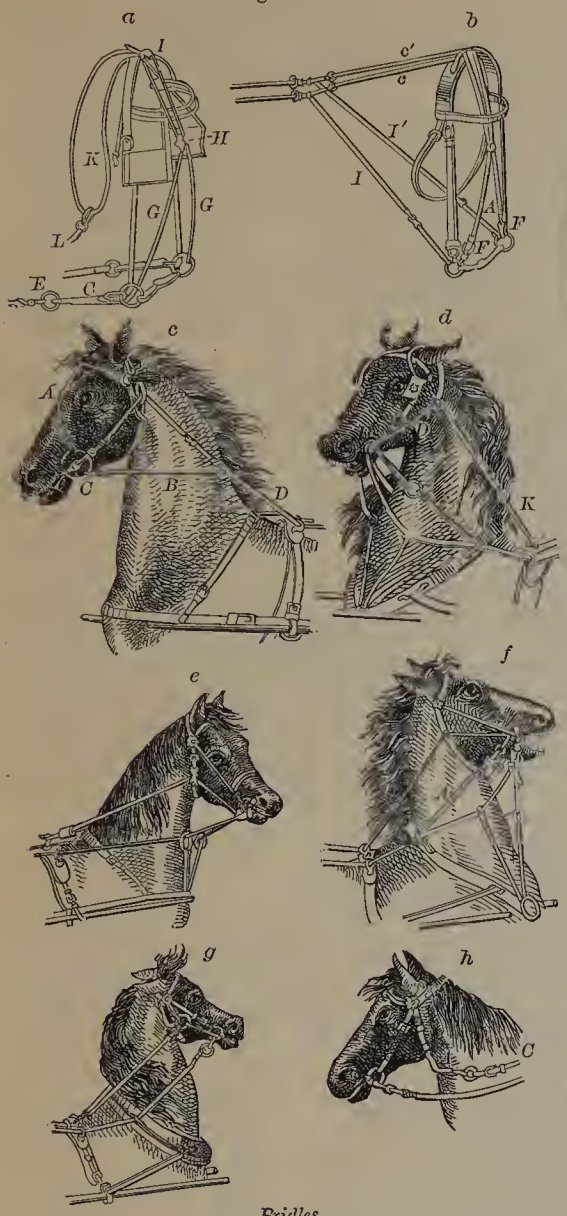
In *a* the driving-reins are attached at *E* by a gum-elastic strap and snap-hook *C* to the rings of the snaffle-bit. Face-pieces *G G'* are also attached to these rings, passing upward through the loops *H I*, and uniting to form the throat-latch *K*, to which the hitching-strap *L* is secured. The combined throat-latch and face-piece prevents the bridle slipping, as the draft upon the hitch-strap draws the ring into the angles of the mouth. In driving, a pull on the lines stretches the gum, which attaches the driving-reins to the rings of the bit, and draws upon the face-straps and throat-latch to pull the bit into the angles of the mouth.

b. Two pairs of branch-reins are attached to the ends of the driving-lines, one *I I* leading directly to the bit-rings, and the other *c c'* passing over the horse; its lower branches *A* connect with the same rings by a spiral spring within cases *F*.

c. The overdraw-strap *A* and check-rein *B* are secured to the bit-ring *C*, and the driving-rein *D* to a swivel on the bit. The driving-rein passes through a ring on the end of the overdraw-strap, and is also connected to the check-rein. A strong pull on the driving-rein throws up the horse's head and prevents him from kicking.

d. The bit-ring *F* is suspended on each side from a ring *D* on the cheek-strap by a running strap, which, connected primarily to the bit-ring, passes up and down through the check-ring; the run-

Fig. 929.



Bridles.

ning-strap is then carried down through the bit-ring and connected by a ring to a safety-rein *I*. The latter is also connected to the gag-rein *K*, so that pulling upon the safety-rein shortens the gag-rein, and at the same time draws up the bit toward the ring on the cheek-strap.

e. The driving-reins run over pulleys attached to the bit-rings and throat-latch, and thence pass to the check-hook. Stops on the cheek portion of the rein limit the length of the gag part.

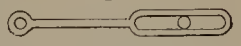
f. This bridle has a safety attachment formed by supplemental reins *A* within the ordinary reins, and which, connecting directly to the cheek-straps, pass through the rings of the bit, and serve to forcibly pull the bit into the corners of the mouth.

g. The driving-rein connects with the cheek-strap, which is pulled through the bit-ring, and draws the bit up into the angle of the mouth.

h. A lever-jaw *A* on each side is suspended from the throat-latch of the bridle. The jaws are kept apart by a spring, but by pulling on the rein *C* may be brought together, so as to compress the horse's windpipe and choke him into submission.

2. (*Mach'nery.*) *a*. A link attachment, limiting the separation of two pieces.

Fig. 930.



Bridle.

b. Of a slide-valve; the flanges which keep it in place, and serve to guide and limit its motion.

3. (*Nautical.*) *a*. One of the ropes by which the *bowline* is fastened to the *leech* of a sail.

b. A mooring-hawser.

4. (*Husbandry.*) The piece on the forward end of a plow-beam, to which the draft-shackle is attached. The *clevis*. Also called the *muzzle* or *plow-head*. See PLOW.

5. (*Fire-arms.*) That piece in a gun-lock which serves to bind down the sear and tumbler, and prevent their lateral motion.

Bri'dle-bit. Bridle-bits are of great antiquity, as is proved by the Egyptian and Assyrian paintings and sculptures. Xenophon (400 B. C.) describes several kinds, smooth, sharp, and toothed. The curb is a modern invention, and was introduced into England from the Continent in the reign of Charles I.

The command exercised by the bit has led to the use of it in metaphor, as in a remarkable passage of James in his Epistle general: —

"Behold, we put bits in the horses' mouths that they may obey us."

Etruscan and Grecian sculpture represent the bridle substantially as we yet have it.

The Greeks had a severe bridle, armed with teeth, which came over the nose like the *cavezon*, a European bit but little known among us. Another rough bit was also known as a *lupaton*, owing to its sharp prongs like wolves' teeth.

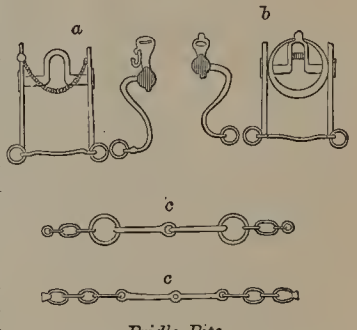
Bridle-bits may be classed under three heads: *snaffles*, *curb-bits*, and *stiff bits*.

The *snaffle* (*c*, Fig. 931) has two bars, jointed together in the middle of the mouth, and has rings at the ends for the rein. It sometimes has cheek-pieces, to keep the ring from pulling into the mouth of the animal.

The *curb-bit* consists of the following parts: —

Cheek-pieces or *branches* with eyes for the *cheek-straps* and for the reins, and holes for the curb-chain; a *mouth-piece*, uniting the *check-pieces* and forming the bit proper; sometimes a bar uniting the lower ends of the branches; a *curb-chain*.

Fig. 931.



Bridle-Bits.

In the Mexican bit the curb-chain and its strap are replaced by a curb-ring.

By means of the branches, a leverage is obtained upon the horse's jaw, the curb-chain behind the jaw forming the fulcrum.

The illustration shows bits employed in the United States military service.

a, ordinary curb-bit.

b, Mexican bit.

c c, watering bridle-bits or *snaffles*.

The *stiff bit* (*a*, Fig. 932) has rein-rings at the ends, and is usually without branches. It lacks the middle-joint of the *snaffle*.

b is a new form of upper-jaw bit. It is fastened by a nose-strap to the upper jaw, and buckled to the gag bearing-rein. A safety-rein passes to the usual bit-rings, and is also connected to the bearing-rein, so as to pull the usual bit back against the jaws,

and the upper-jaw bit up into the angle of the mouth.

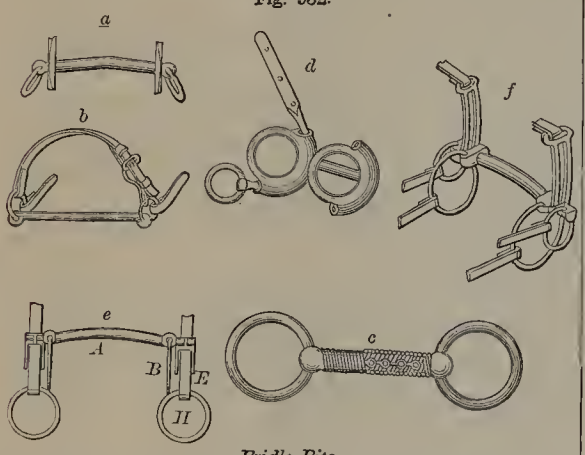
The *elastic bit* (*e*) consists of a chain covered by closely coiled wire between the bit-rings.

Another form of elastic bit is made of twisted wire with a soft rubber covering.

A large number of contrivances have been patented for giving a greater command over the horse, by means of pulling the bit upwardly into the angle of the mouth instead of pulling against the jaw. See BRIDLE.

d has tubular bit-rings through which pass the straps connecting the driving-reins to the head-stall. When the lines are pulled upon, besides drawing the bit against the jaw, the line slips through the tubular bit-rings, and draws the stiff bit up into the angle of the mouth. The illustration shows one bit-ring empty and the other with the strap passing through it.

Fig. 932.



Bridle-Bits.

e has a pulley-frame swiveled to the ends of the bit *A*; the driving-reins are buckled to the rings *H*, and when they are pulled, the straps *E* run through the pulleys and draw the bit up into the angle of the mouth. The rings *B* are for the bearing-rein. As the pulley-frames are swiveled, the bit is carried upward into the mouth without turning the bit in the mouth. The pulley-frames are removable when required, so as to leave the bit in the ordinary condition.

The bit *f* is designed to effect the same purpose. One rein is connected to the bit-ring and the other to the slotted cheek-pieces; when the latter rein is pulled, the rigid bit slides up the slots and is drawn into the corners of the mouth.

Bri'dle-ca'ble. (*Nautical.*) A cable proceeding from a vessel to the middle of another cable which is moored at each end.

Bri'dle-port. (*Shipbuilding.*) A port in the bow for a main-deck chase-gun; through it mooring-bridles or bow-fasts are passed.

Bri'dle-rein. A rein passing from the hand to the bit, or from the check-hook to the bit, or, in wagon-harness, from the top of the hames to the bit.

The bridle-rein may be a *check*-rein, *gag*-rein, or a *riding-bridle* rein; the latter a *snaffle* or *curb*-rein, according to the kind of bit.

Bri-doon'. (*Saddlery.*) 1. The snaffle-bit and rein used in European military equipments in connection with a curb-bit which has its own rein.

2. In the United States the term is sometimes applied to a simple snaffle without cross-bars, and having a rein attached to its rings.

Bri'er-scythe (*Husbandry.*) A stout, short-bladed scythe in a nearly straight handle, and used for cutting down brambles and the like.

Bri'er-tooth Saw. A saw whose interdental spaces are deeply depressed by oblique filing on alternate sides. See GULLET-SAW.

Brig. (*Nautical.*) A two-masted vessel, square-rigged on both masts. It has a gaff-sail on each lower mast; that on the mainmast is called the driver. When the driver is bent to rings on a try-sail mast, just abaft the mainmast, the vessel was formerly called a *snow*.

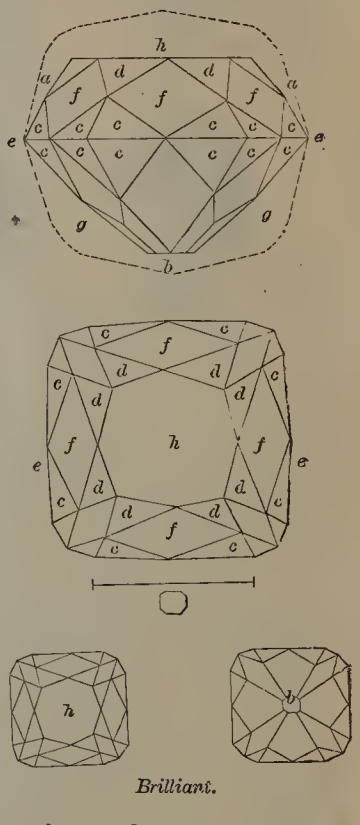
A hermaphrodite brig is a vessel rigged as a *brig* on the foremast and like a *schooner* on the main-mast, carrying *square* sails forward and *fore-and-aft* sails abaft.

Brig'an-tine. (*Nautical.*) A two-masted vessel brig-rigged on the foremast, but having no lower square sail on the after or mainmast.

Bril'liant. 1. (*Diamond-cutting.*) A mode of cutting gems, consisting of lozenge-shaped facets alternating with triangles. The variations are known as the *half brilliant*, *full brilliant*, *split* or *trap brilliant*, *double brilliant* or *Lisbon cut*. See CUTTING GEMS.

A diamond cut as a brilliant has two truncated portions, respectively above and below the *girdle*, which is at the largest circumference. The upper portion, which projects from the setting, is called the *bizet*, and is one third of the whole depth of the gem. The remaining two-thirds is imbedded, and is called the *culasse*. The facets of the bizet and the culasse have consequently different inclinations and exhibit different figures, as will be apparent from the illustrations.

Fig. 933.



Brilliant.

A well-cut brilliant, held in a beam of light, reflects nearly the whole of the light which falls upon it, throwing it out and refracting it in colored rays through the facets in front. With the exception of one small point of light through the *collet*, the brilliant throws an opaque shadow on a screen.

a. Bizet; the chamfered portion of the stone between the *table* and the *girdle*.

b. Collet; the horizontal face at the bottom of the stone.

Facet; small, triangular faces.

c. Skew or *skill facets;* divided into *upper* and *under*, and respectively wrought upon the *bizet* and *pavilion*, in each case terminating in the *girdle*.

d. Star-facets; wrought on the bizet, and terminating in the *table*.

e. Girdle; the line encompassing the stone; its outer edge by which it is grasped in mounting.

f. Lozenges; rhombal facets formed on the bizet by the *star* and *skill facets*.

g. Pavilion; the chamfered portion of the stone between the *girdle* and *collet*.

h. Table; the horizontal face at the top of the brilliant.

2. (*Printing.*) A very small type, smaller than Diamond.

Pearl.
Diamond.
Brilliant.

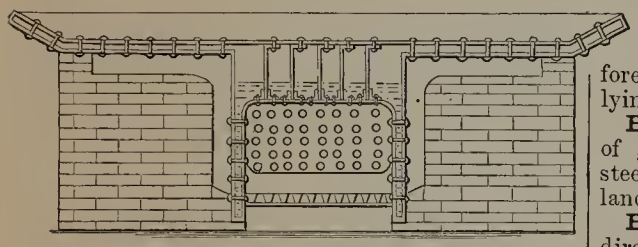
3. (*Fabric.*) A cotton goods woven with a small raised pattern, and printed or plain.

4. (*Pyrotechny.*) A form of pyrotechnics for making a bright light. The filling is gunpowder 16 and steel-filings 4; or, gunpowder 16, borings 6.

Brin. One of the radiating sticks of a fan, from 12 to 24 in number and about 14 inches long. The outermost are larger and longer, and are called *panaches*.

Brine-e-vap'o-ra-tor. An apparatus for evaporating brine, in order to produce salt. The common furnaces for this purpose have a row of pans set

Fig. 934.



Platt's Brine-Evaporator.

above a long arch; shelving sides hold the salt as it is dipped out, and allow it to drain into the kettles. In the illustration the pan bottom is double, forming a steam-jacket; the multiflue boiler forms a jacket around the fuel-chamber. The flame and heat, after direct passage through the flues, pass backwardly alongside the furnace-jacket and beneath the steam-jacket of the pan.

The following United States patents may be consulted: —

Guiteau	1842.	Garrison	1862.
Hull	1855.	Hull	1863.
Humphreys	1856.	Farrar	1863.
Heims	1859.	Platt	1869.
Pratt	1862.	Gilson	1870.
Chapin	1862.	Howarth	1871.

Brine-pump. (*Steam-Engine.*) A pump worked by the engines to withdraw the super-salted water from the boilers mechanically, instead of by periodical blowing off.

Maudslay and Field's English Patent, 1824, describes a brine-pump with a loaded discharge-valve worked by the engine, and so proportioned as to draw from the lower part of the boiler the quantity determined on, which may be regulated by a meter, showing the quantity driven off in the form of steam. After the boiler has been in action some time, and the water has received a predetermined degree of concentration, the brine-pump is started to work, and every stroke takes from the boiler as much salt as is deposited in the boiler by the separation of the steam used in that stroke. The hot brine so withdrawn is used to heat the boiler-supply.

Brine-valve. (*Steam.*) A valve which is opened to allow water saturated with salt to escape from the boiler. A *blow-off* valve.

Bring'ing-to Bolt. One used in keying up a structure. It may be a *screw* or a forelock bolt.

Bring'ing-up. (*Printing.*) The operation of overlaying, underlaying, cutting out, etc., for equalizing the impression or giving the proper prominence to the dark and light parts of woodcuts.

Bris'tle. Bristles for brush-making are assorted according to color.

Washed with potash-lye and soap, to free them from animal fat.

Whitened by bleaching them with fumes of brimstone.

Combed with a steel comb, to lay them parallel and remove the short hair with which they may be mixed.

Sorted by continually pulling out the longer hairs from the bunch, butting the end of the bunch on the bench.

Bound in bunches called *knots*, which are inserted in the bored holes in the brush-backs, and tied and glued in position.

The face-ends of the bunches are then sheared.

Machines are in use, and some patented for —

Assorting bristles.	Cleaning bristles.
Bunching bristles.	Washing bristles.

Bris'tol-board. (*Paper.*) A superior article of cardboard, in which all the sheets of paper composing it are white, and erasures may therefore be made without exposing an inferior underlying quality. See Cardboard.

Bris'tol-brick. A brick composed principally of granular silicious matter. Used for polishing steel, etc. The name is derived from Bristol, England, near which city they are made.

Bris'ure. (*Fortification.*) A break in the general direction of the parapet of the curtain, when constructed with *orillons* and retired flanks.

Brit-an'nia-met'al. A white-metal alloy, resembling silver in some degree, and used for making table-ware, etc.

There are several formulas for compounding this white alloy for table-ware: —

	Copper.	Tin.	Antimony.	Bismuth.	Brass.	Zinc.
Lardner's	8	392	28		8	
Overman's	3	88	7			1
Another	1	1	2			
Another		4	4	4	4	
Another	2	100		2	8	

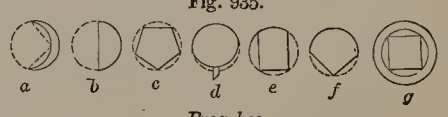
See *ante*, White-Metal Alloys, p. 63.

Brit'ish-gum. An adhesive material, used by calico-printers, and made by scorching potato-starch.

Britz'ska. (*Vehicle.*) A Russian carriage, having a calash top and interior arrangements adapted for use as a couch on long journeys.

Broach. 1. A tapering steel tool, of prismatic form, and whose edges are used for reaming out holes. It is particularly used by watchmakers in enlarging holes in watch-plates. When smooth, it is

Fig. 935.



Broaches.

no longer a broach, but a burnisher, and is used for burnishing pivot-holes. The number of sides vary; the smaller the number, the more salient is the edge.

Broaches are also used by dentists for enlarging the nerve canals of the teeth for the insertion of the dowel-pins which secure *pivot-teeth*.

The end of a broach has as many facets as the shaft has sides, and the tang is 4-sided.

a is the carpenter's broach for reaming out holes in wood. The angle of its edges would be inadmissible in metal as hard as copper.

b is a half-round broach. The edges are rectangular.

c has five sides with angles of 108°.

d has but two facets and an inserted steel cutter at their angle.

e has angles of 90°, and but three facets; the rounded back follows the circle of the hole.

f has one angle of 90°.

g represents the gun-barrel broach of four sides; slips or spills of segmental form occupying the spaces between the rectangular broach and the circumscribing cylinder.

Broaches of 3, 4, 5, 6, 8 sides have respectively angles of 60°, 90°, 108°, 120°, and 135°. The polygonal broaches are the most commonly used.

Broaches twisted while hot have an increased energy of bite, when rotated in the direction of the spiral, and less when rotated in the other direction.

ROBERTS's broach (English) has longitudinal cutters inserted in grooves at each angle.

Some *broaches* have file teeth to enable them to cut with a thrust, without rotation. These are more properly *drifts* (which see).

A round broach is used for burnishing pivot-holes.

2. A gimlet used in opening casks for samples. The hole is closed by a spile.

3. (*Candle-making.*) The stick from which candle-wicks are suspended for dipping.

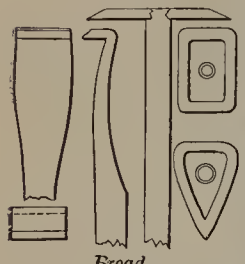
4. (*Husbandry.*) A sharpened stake used by thatchers to secure the gavels or layers of straw.

5. (*Locksmithing.*) That pin in a lock which enters the barrel of the key.

Broach-post. (*Carpentry.*) A *king-post.*

Broad. (*Wood-turning.*) A bent turning-tool, or one formed of a disk, with sharpened edges secured to a stem. Used for turning down the insides and bottoms of cylinders in the lathe. Fig. 936 shows several different forms of the tool, — the bottom-tool, hook-tool, square-tool, heart-shaped tool.

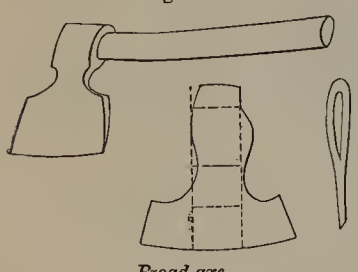
Fig. 936.



Broad.

Broad-axe. An axe with a broad edge, for hewing timber. The chamfer of the edge is all on one side, the flat side of the bit going against the wood. The handle has a crook, so that the knuckles are not grazed against the timber when hewing.

Fig. 937.



Broad-axe.

The Israelites west of the Jordan had but small advantages of timber, and were not skillful hewers. They imported axemen and timber. Lebanon had cedar and fir; Bashan had oak. The kings of Syria and Egypt fought for their possession for centuries. Even firewood was scarce in Judea and Samaria. The poor widows gathered a bundle of sticks then as now.

Dung and hay used for heating ovens, Ezekiel iv. 12–15, Matt. vi. 30.

Brushwood also, — "as the crackling of thorns under a pot," etc.

Broad'cast Sow'er. (*Husbandry.*) A machine which spreads the seed regularly upon the surface of the ground, in contradistinction to a drill which sows the seed in rows.

Number of several seeds in a bushel, and number per square foot upon an area of an acre: —

	Number.	Square Foot.
Timothy	41,823,360	960
Clover	16,400,960	376
Rye	888,390	20.4
Wheat	556,290	12.8

The Egyptians and Romans sowed from a basket. In the West we prefer a bag or sack which is made into a pouch by tying the bag-string to one corner of the bottom. Pliny mentions that it is important for the action of the hand and feet to keep time, to secure an even spread of the seed. It is just so with us. A right-handed man will dip his hand into the bag for seed just as his left foot touches the ground. Some sow with both hands.

Under the Romans, the amount of seed to the *jugerum* (four fifths of an acre) was, of wheat, spelt, and barley, respectively, 5, 10, and 6 *modii*. A *modius* was two gallons.

Broad'cloth. (*Fabric.*) A wide and superior article of woolen cloth, plain or twilled, and dyed in the wool or the piece. A cloth not over 29 inches broad is a *narrow* cloth. It is folded lengthwise in the piece.

The operations in broadcloth-making may be shortly cited as follows: —

The wool, being shorn, goes to the sorter, who selects the grades and parts of fleeces adapted for this superior kind of goods.

Oiled, carded, and spun into yarn.

Woven into a web of such a width as to permit subsequent shrinkage.

Felted by wetting, soaping to remove grease, and pounding. The effect is to condense it and shrink it in width and length. After removal of the soap by fuller's earth, water, and pounding, the web is dried by stretching on tenter-bars.

Napped on a gigging-machine, which raises the nap by the little recurved spires of the teasel (*dipsacus fullonum*).

Shorn to bring the naps to a length.

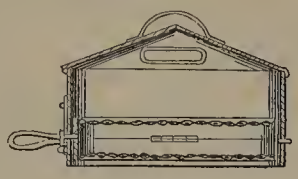
Hot-pressed to give smoothness and polish.

Broad-gage. (*Railway Engineering.*) A distance between rails over 56½ inches. The width of 4 feet 8½ inches was adopted by Stephenson, being the usual grade of the coal-wagons on the railways in the North of England. He found it, did not make it. Brunel, who was not used to following anybody, either under or above ground, struck out a path for himself, and gave the broad-gage to the Great Western Railway of England, making it 7 feet. It was a very expensive experiment, and has been reduced to the standard of 56½ inches. See RAILWAY-GAGE.

Broad-glass. Glass in large sheets for cutting into *lights* or *panes*. For very many years, the mode of making sheet-glass was by forming a disk, which was united to the blowing-tube by a boss, around which point the glass was also much thicker than at other portions, especially near the periphery of the disk. See CROWN-GLASS. Owing to the vexatious excise laws of England, it was almost impossible to introduce improvements in the manufacture of glass, as was illustrated in the abortive attempts of the English opticians to manufacture lenses of large sizes, even under semi-official sanction. The general relaxation of the excise system under Sir Robert Peel's Act of 1846, rendered possible the introduction into England of an improved method, for some time then past in use in France and Belgium. The glass used upon the Exhibition Building of 1851 was made upon this plan, which is briefly as follows: —

The workman dips his iron tube into the semi-viscid glass, and takes up a quantity amounting to 12 or 14 lbs.; he rolls the mass on a wooden block,

till it assumes a cylindrical shape; he applies his mouth to the other end of the tube, and blows until the mass assumes a hollow ovoid form; he whirls this round his head, or, rather, in a vertical circle 10 or 12 feet in diameter, and elongates the ovoid into a cylinder with round ends; he re-heats the glass two or three times during these processes, to maintain the proper consistency, and at length the remote end of the hollow mass gives way, and we have before us a cylinder of glass, attached only at one end to the tube. The cylinders are dissevered from the tube, and are cut lengthwise with a diamond; they are placed in a kiln, where the heat gradually opens the fissure, and there is finally presented a flat piece of glass, which can be cut to any smaller size.



This glass is called *broad-glass*, *cylinder-glass*, *sheet-glass*, and by several other names of minor usefulness, value, or appropriateness. See CYLINDER-GLASS.

Broad-horn. The old-fashioned term for the flat-boat of the Western and Southwestern rivers. Also called an *ark*.

Broad-pen'nant. (*Nautical.*) A square piece of bunting carried at the mast-head of a vessel having in command an officer of a certain rank. In the British and American navies it signifies a commodore's vessel.

Broad'side. 1. (*Printing.*) A sheet of paper printed on one side, the matter forming a single page.

2. (*Nautical.*) *a.* The side of a ship, above the water, from the bow to the quarter.

b. All the guns, collectively, carried on one side of a war vessel.

Broad'sword. A sword with a broad blade, designed principally for cutting.

Broad'stone. (*Masonry.*) An ashlar.

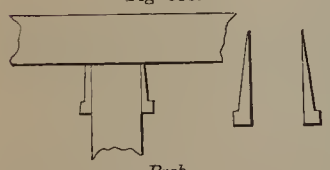
Broad-tool. 1. (*Masonry.*) A stone-mason's chisel which has an edge 3½ inches wide. It is used for finish-dressing. The previous tools are the *point* or *punch*, *inch-tool*, and *boaster* (two inches wide).

2. (*Turning.*) A BROAD (which see).

Broad Win'dow-glass. Glass blown of a cylindrical form, split longitudinally, and spread flat. See BROAD-GLASS; CYLINDER-GLASS.

Brob. (*Carpentry.*) A peculiar form of spike driven alongside a timber which makes a butt-joint against another, to prevent the slipping of the former. For instance, several *brobs* are driven round a post which supports a roof-timber in a tunnel or gallery.

Fig. 938.



Brob.

Bro-cade'. (*Fabric.*) A rich, stout silk. A common name for any kind of stuff wrought and enriched with raised flowers. In the East, a cloth of gold and silk. The manufacture of brocade was established at Lyons, in 1757.

Bro-ca-telle'. (*Masonry.*) A kind of marble whose color is a mixture of gray, yellow, red, and dove shades.

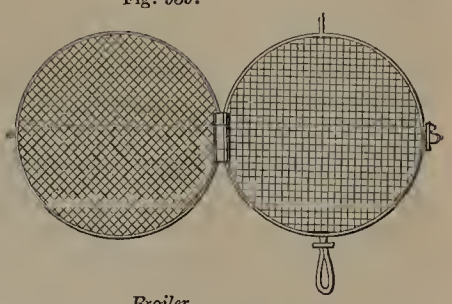
Bro-ca-tel'lo. (*Fabric.*) A coarse brocade of cotton, or silk and cotton.

Bro-ché-goods. (*Fabric.*) Goods embroidered or embossed.

Brog. A joiner's awl.

Broil'er. (*Domestic.*) A gridiron. The later devices have provision for turning the grids so as to expose each side of the meat alternately to the action of the fire.

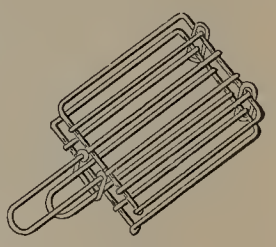
Fig. 939.



Broiler.

In the upper example the gridiron is made in two parts, hinged together, and so that it may revolve and expose both sides of the meat, which can be examined during the cooking process by means of a transparently-covered opening in the top of the case. The grids are pivoted within a covered case.

Fig. 940.



Broiler.

In the other example it is simply a double frame with means for locking together.

Brok'en-space Saw. A fine hand-saw.

Brok'en Twill. (*Fabric.*) A variety of *twill* in textile fabrics.

Bron'cho-tome. (*Surgical.*) A knife used in the operation of cutting into the *bronchus*, or windpipe. Asclepiades, who lived at the beginning of the first century B. C., proposed the operation of bronchotomy, though it is not certain that he performed it.

It was practiced three hundred years afterward by Antyllus, and was particularly described by Paulus Æguieta about A. D. 780.

Bron'tern. A brazen vessel in the basement below a stage, to imitate thunder.

Bronze. 1. An alloy composed of copper and tin, sometimes with a little zinc and lead. The "Big-Ben" bell of Westminster, the largest bell in England, is composed of 22 parts copper, 2 parts tin. Gun-metal is a bronze, 9 parts copper, 1 of tin. It is probable that some of the ancient alloys which we read of as "brass" were really bronze. The Phœnicians brought tin from Cornwall 1100 B. C., before the building of Solomon's Temple. See BRASS.

"Tarshish was thy merchant [Tyre]; with silver, iron, tin, and lead they traded in thy fairs."

The tin of Cornwall, and also probably that from the peninsula of Malacca, was mixed with the copper of the Wady Maghara to form the Egyptian, Phœnician, and Assyrian bronzes. Dr. Wilson (*Prehistoric Man*) supposes that tin was first brought to the Mediterranean from Malacca, and gave a new impetus to early Eastern civilization. Britain was the next source. Chili and Mexico are more lately known as productive sources of the same useful metal.

The ordinary Assyrian bronze is composed of copper 10, tin 1. Their bell-metal was, copper 86, tin 14.

The ancient bronze cutting-tools contained from 4 to 15 per cent of tin, from which it is gathered that the secret of their manufacture is rather in their mode of working and tempering than in their com-

position. This appears to be also the case with Chinese cymbals and tam-tams, whose tones are not rivaled by the instruments made by European artists, though analysis of the alloy fails to disclose any reason for this. Bronze, containing 20 per cent of tin, is brittle at the ordinary temperature, becomes malleable at a dull red heat. See ANNEALING.

Bronze is the oldest alloy with which we are acquainted, and is assumed to have preceded the use of iron in the majority of countries which have passed through the various stages. It is not a violent assumption that the stone and bone implement age preceded the age of copper tools; that the latter was the first metal which was used in the mechanic arts; that the alloying of copper with tin to harden it preceded the use of iron (see ALLOY); that brass (copper and zinc) was a discovery later than either (see BRASS); that the first iron utilized was of the nature of steel, as yet produced in many countries of Europe, Asia, and Africa by the native metallurgists. In speaking of ages, no general world-wide area of contemporary progress is intended. There are tribes yet in the bone age (see AXE), others in the bronze. Some of the bone men have jumped into the iron (which they purchase) because they had no copper, and iron was the first metal with which they became acquainted; such are some of the South Sea Islanders.

Hesiod, 900 B. C., states that iron was discovered after copper and tin, and that those who were ancient, in his day, used bronze. Lucretius mentions also the gradation: —

"The primeval arms were the hands, the nails, and the teeth,
Together with stones and branches, the fragments of the forests;
Afterwards was found the power of iron and of bronze,
But the use of bronze was known before that of iron."

Bronze implements are obtained by casting, and, it is believed, by subsequent hammering while hot. (See *supra.*) Bronze and copper were cast in ancient Egypt; the Chinese state that Yu, who was semi-king with a partner (Chun) on the throne of China, 2200 B. C., caused nine vases to be cast, on which were engraved maps of the nine provinces of the Empire. The Greeks, Etruscans, and the pupils of the latter, the Romans, excelled in the art; and the museums of Europe have almost numberless specimens of their art in statuary, household utensils, and ornaments. When the Spaniards first entered the province of Tuspan, they mistook the bright copper or bronze axes of the natives for gold, and were greatly mortified, after they had accumulated them in considerable numbers, to discover the mistake they had made. Bernal Diaz narrates that "each Indian had, besides his ornaments of gold, a copper axe, which was very highly polished, with the handle curiously carved, as if to serve equally for an ornament as for the field of battle. We first thought these axes were made of an inferior kind of gold; we therefore commenced taking them in exchange, and in the space of two days had collected more than six hundred; with which we were no less rejoiced, as long as we were ignorant of their real value, than the Indians with our glass beads."

Ancient American Bronzes.	Copper.	Tin.	Iron.
Chisel from silver-mines, Cuzco	94	6	
Chisel from Cuzco	92.385	7.615	
Knife from grave, Atacama	97.87	2.13	
Knife	96	4	
Crowbar from Chili	92.385	7.615	
Knife from Amaro	95.664	3.965	0.371
Perforated axe	96	4	
Personal ornament, Truigilla	95.440	4.560	
Bodkin from grave	96.70	3.30	

The bronzes of Europe took a much wider range of variation.

	Copper.	Tin.	Lead.	Iron.
Spear-head, Lincolnshire	86	14		
Bronze vessel, Cambridgeshire	88	12		
Flexible nails	20	1		
Sword, France	87.47	12.53		
Medal	100	8 - 12		
Axe-head, Mid-Lothian	88.5	11.12	0.78	
Caldron, Duddingstone	84.8	7.19	8.53	
Mirrors	100	30 - 50		
Sword, Ireland	83.50	5.15	8.35	3
Sword, Thames	89.69	9.58		0.33
Axe-head, Ireland	89.33	9.19		0.33
Drinking-horn, Kings Co., Ireland	79.34	10.87	9.11	
Wedge, Ireland	94	5.9		0.1

See also Brasses and Bronzes, with the addition of Iron, p. 61.

	Copper.	Tin.	Zinc.	Lead.	Arsenic.	Iron.	Aluminium.
Statuary bronze	91.4	1.4	5.5	1.7			
Church bells	80	10.1	5.6	4.3			
Church bells	16	3 - 5					
Clock bells	72	26.5				1.5	
Gun-metal	9	1					
Gongs	81.6	18.4					
Cymbals	4	1					
Lathe-bushes	80	20					
Machinery bearings	7	1					
Machinery bearings, hard	77.4	15.6	7				
Speculum metal	66	22			12		
Speculum metal	7	4	3				
Speculum metal	50	29	21				
Speculum metal	6	2		1			
Speculum metal (Lord Rosse)	126.4	58.9					
Aluminium bronze	90						10

Coolcy's recipes for bronze: —

	Copper.	Tin.	Zinc.	Lead.
For edge-tools	100	14		
For gilding	82	3	18	2
For medals	89	8	3	
For medals (M. Chaudet)	95	4		
For mortars	93	2		5
For statuary	88	9	2	1
Or (Statue, Louis XV.)	82½	5	10½	2
Or	91	9		

Alloys into which aluminium enters, either in combination with copper alone, or with that and other metals, are usually termed aluminium bronzes; the composition of some of these is given below: —

	English Patent, 2,768 of 1862.	English Patent, 3,159 of 1862	English Patent, 42 of 1863.	English Patent, 2,285 of 1867.	Minargent.	Gold-colored.	Hard white.	Malleable white.	Hard bronze.	Non-oxidizable.	Baur's, 1863.	Paris gold-colored.
Aluminium	7.5	7.5	13.70	10	1	1	100	2	10	25	3	10.5
Iron			27.18							75		
Copper	92.	90	31.71	100	100	10		10	90		16	89.3
Platinum			98.84									
Tin			58.92									
Nickel			29.62	70	70							
Silver			108.30				5					
Zinc			32.31								10	
Gold		2.5										
Tungsten				5	5							

See also Aluminium Bronze, pp. 70, 71.

2. (*Cotton-manufacture.*) One style of calico-printing, peculiar rather from the character of its colors, than from any specific novelty in treatment.

Bronze Pow'der. Finely pulverized metal, or powder having a metallic base, applied to the surface of paper, leather, and other materials, for imparting a metallic color and luster.

1. *Gold powder* for bronzing is made by grinding leaf-gold with honey; dissolving the mixture to obtain the gold by deposition, the honey water being decanted.

2. *German gold* is a yellow-alloy leaf similarly treated.

3. *Mosaic gold* is prepared by incorporating and grinding tin, 16; flower of sulphur, 7; mercury, 8; and sal-ammoniac, 8; and then subliming the amalgam. A flaky gold-colored powder remains in the matrass.

4. *Copper powder* is obtained by saturating nitrous acid with copper, and then precipitating the copper by exposing iron bars in the solution.

5. Bisulphide of tin. It has a golden luster, flaky texture, and is used for ornamental work, such as paper-hangings, and as a substitute for gold-leaf.

6. Dutch foil reduced to a powder by grinding.

7. Verdigris, 8; tutty powder, 4; borax, 2; niter, 2; bichloride of mercury, ¼; grind into a paste with oil, and fuse them together.

8. (Iron-colored) plumbago in powder.

9. (Red) sulp. copper, 100; carb. soda, 60; mix and incorporate by heat; cool, powder, and add copper filings, 15; mix; keep at a white heat for twenty minutes; cool, powder, wash, and dry.

Bronz'ing. The process of giving a bronze-like or antique-metallic appearance to the surface of metals.

The processes vary; they may be classed as —

Coating with a melted alloy.

Coating with a metal in paste, solution, or vapor.

Corrosion.

Coating with a gum.

Application of bronze powder.

Painting.

The modes vary with the material: —

I. As to copper (some of them applicable to brass).

1. The surface is cleaned, polished, and a paste of crocus powder and water applied to it. Apply heat to develop the color required.

2. Plumbago applied in the same manner. By employing mixtures of plumbago and crocus, different shades are obtained.

3. The copper is exposed at a high heat to the fumes of zinc.

4. The copper vessel is filled with a water acidulated with hydrochloric acid, an amalgam of zinc and cream of tartar being added. Boil for a while.

The latter two processes are more properly *brassing*.

5. Corrosion processes: —

a. Wash the cleaned copper with a dilute solution of sulphuret of potassium, or hydrosulphuret of ammonia is applied with a brush.

b. Apply solution of verdigris, 2; sal-ammoniac, 1; and vinegar, 16.

c. Or, verdigris, 2; vermilion, 2; alum, 5; sal-ammoniac, 5; vinegar sufficient to form a thin paste. Blue vitriol inclines to dark brown, borax to yellow brown.

d. Or, sal-ammoniac, 1; cream tartar, 3; common salt, 3; hot water, 16; dissolve, and add nitrate of copper, 3, dissolved in water, 8; apply repeatedly with a brush.

e. Or, salt of sorel, 1; sal-ammoniac, 3; distilled vinegar, 32; apply as above.

f. Or, a weak solution of chloride of platinium.

II. As to iron: —

a. Clean the metal, and wash it with or immerse it in a solution of sulphate of copper or verdigris, when it will acquire a coating of copper.

b. The metal may be dipped in molten metal, copper, or its alloys.

c. The polished metal — a gun-barrel, for instance — may be dropped in a solution of chloride of antimony and sulphate of copper. This is *browning*.

d. The ordinary solution consists of: aquafortis, 1; sweet spirits of niter, 1; blue vitriol, 4; tincture of the muriate of iron, 2; water, 32.

e. Or, blue vitriol, 1; sweet spirits of niter, 1; water, 16.

f. The iron is cleaned, polished, coated with linseed-oil, and heated to develop the tint required. Tucker's patent, Dec. 15, 1863.

g. The iron is cleaned, polished, and lacquered. The lacquer consists of shell-lac in alcohol, with or without the addition of saffron, annotto, aloes, or other coloring substances.

h. The iron is painted with a *gold*-paint, so called; Dutch metal and varnish.

i. The iron is painted green, and rubbed with bronze powder.

III. As to tin: —

Clean the castings, and wash them with a mixture of 1 part each of sulphate of copper and sulphate of iron in 20 parts of water; dry and wash again with a solution of verdigris, 5 parts; in distilled vinegar, 11 parts. When dry, polish with colcothar.

IV. As to plaster: —

Plaster-of-paris statuettes, medals, etc., may be bronzed in the following manner: —

Prepare a soap from linseed-oil boiled with caustic soda lye, to which add a solution of common salt; and concentrate it by boiling, till it becomes somewhat granular upon the surface; it is then strained through a linen cloth, and what passes through is diluted with boiling water, and again filtered. Dissolve 4 parts of blue vitriol and 1 part of copperas separately in hot water, and add this solution to the solution of soap as long as it occasions any precipitate. This flocculent precipitate is a combination of the oxides of copper and iron with the margaric acid of the soap, the former giving a green and the latter a reddish-brown color, the combination of the two resembling that grecnish rust which is characteristic of ancient bronzes. When the precipitate is completely separated, a fresh portion of the vitriol solution is to be poured upon it in a copper pan, and boiled in order to wash it. After some time the liquid part is poured off, and the soap washed with warm and afterward with cold water, pressed in a linen bag, and drained and dried, when it is ready for use, in the following manner: —

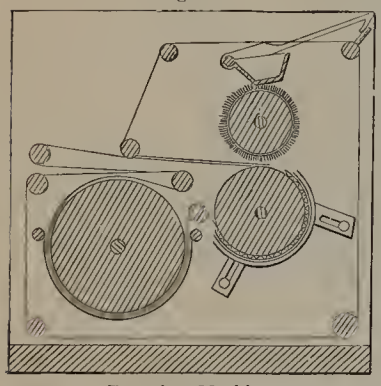
Three pounds of pure linseed-oil are boiled with 12 ounces of finely powdered litharge, and the mixture is strained through a canvas cloth and permitted to stand in a warm place until it becomes clear. 15 ounces of this, 12 ounces of the above-described soap, and 5 ounces of fine white wax, are melted together at a gentle heat in a porcelain basin, by means of a water-bath. The mixture must be kept some time in a molten state, to expel any moisture which it may contain. It is then applied by means of a paint-brush to the surface of the gypsum, which is heated to the temperature of about 200° F. After exposure to the air for a few days the surface is rubbed with cotton-wool or a

fine rag, and variegated with a few streaks of metal powder or shell gold. Small objects may be dipped in the melted mixture and then exposed to the heat of the fire until thoroughly penetrated and evenly coated with it.

The bronze letters and figures upon the bonds and paper currency of the United States — as, for instance, "the faint attempt at a *metallic ring*," as Mr. Secretary Chase called it, on the old twenty-five-cent fractional currency — are made by printing in drying-oil, and applying the metal in fine dust to the damp surface.

Bronz'ing-ma-chine'. A machine for bronzing wall-papers or printed sheets. Those parts of the sheet which are to receive the bronze powder are first printed with letters or figures in ink or size. The machines vary in the special devices for distributing and removing superfluous powder.

Fig. 941.

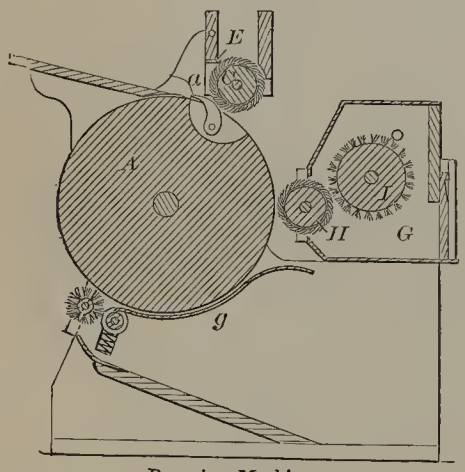


Bronzing-Machine.

In Fig. 941 the freshly printed paper is carried between endless tapes under a fur-covered roller, through a fur-lined box, and around a roller beneath a wiper-apron. It operates by first coating the freshly inked parts with bronze-dust, and then removing the same from between the letters.

In the example (Fig. 942) the freshly printed paper is laid upon the feed-braid, and its edge seized by the gripper *a*, so that the revolution of the wheel *A* carries the sheet past the fur-wheel *C*, which re-

Fig. 942.



Bronzing-Machine.

volves at the bottom of the bronze-hopper *E;* thence past the burnisher *H*, which removes superfluous bronze, and is itself cleaned by the brush *I*, which delivers the bronze into the collecting-box *G*. The sheet then passes between the wheel *A* and apron *g*, and receives a final brushing at the point of delivery.

Brooch. 1. An ornamental clasp with a pin for fastening the dress.

The term corresponds to *ouch* (which see), under which name the ornamental clasp appears in the King James version of the Bible, Exodus xxviii. 11, xxxix. 18, and in other places. See Minshieu's "Ductor in Linguas," 1617; Phillips's "World of Words," 1658. See also the same passages in the "Bishop's" and "Coverdale's" versions. In the "Wickliffe" version it is rendered "hookes."

The *ouch* or *brooch* was a clasp or button, and, in course of time, came to be fastened with a pin called a *broach* (Fr. *broche*), and hence the name *brooch*, of this form of ornamental clasp, has been attributed to the name of the pin (*broach*) by which it is fastened.

This brooch or pin, probably as large as the corking-pin of Swift's time, of old formed a stiletto upon occasion, as among the Athenian dames, who made such pointed inquiries of the man who alone escaped from the slaughter of the party of Athenians who made a raid upon Egina, to capture the olive-wood statues of Damia and Auxesia, plundered by the Eginetans from the Epidaurians. Herodotus, V. 87, says: —

"When he came back to Athens, bringing word of the calamity, the wives of those who had been sent out on the expedition took it sorely to heart that he alone should have survived the slaughter; they therefore crowded around the man, and struck him with the brooches by which their dresses were fastened, each, as she struck, asking him, 'Where did you leave my husband?' and the man died in this way."

The upshot of it was, that the men of Athens were so disgusted at the conduct of the women, that they changed their dress, which was a short Dorian tunic having no sleeves, and fastened over both shoulders by brooches, and compelled them to wear the Ionic linen gown, with short, loose sleeves, and with a skirt reaching to the ankles. "This," Herodotus says, "does not require brooches."

This brooch was not a buckle, but a pin with a hooked head; so it was a broach, after all.

2. A painting all of one color, as in sepia or india-ink.

Brood. (*Mining.*) Any heterogeneous mixture among tin or copper ore; as, mundick, black-jack, etc.

Broom. A domestic utensil for sweeping, made of various materials, most commonly, with us, of the broom-corn, which is a species of doura or sorghum, and came from Africa. Of late years much attention has been directed to the subject of broom-heads, so that, instead of the handle and head being thrown away as useless when the corn is worn out, they are made permanent, with arrangements for clamping the corn and unclamping it, so that it may be removed when worn out, and fresh corn substituted.

Benjamin Franklin introduced broom-corn into this country, previous to which brooms were made of evergreen boughs. It is said that, while examining an imported corn-whisk, he discovered a single seed, which he planted in his garden, and from which the corn was propagated.

Brooms are, however, made of various materials, animal and vegetable.

Among the kinds may be cited (and some of them are really brushes on long handles): —

Carpet.	Hearth.
Coir.	Hickory.
Hair.	Whisks.

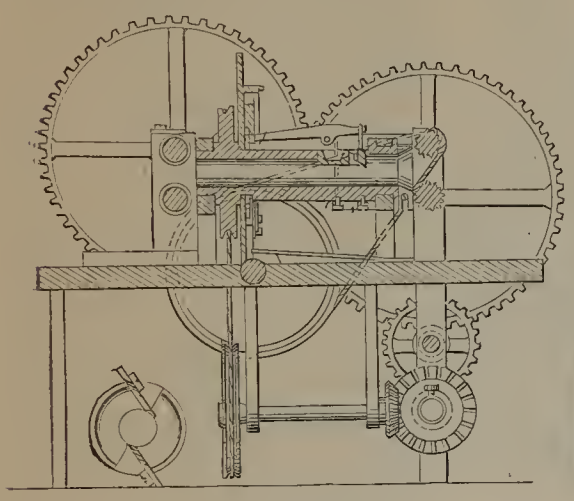
Broom-corn Seed-strip'per. A machine like a flax-*ripple*, for removing the seeds from broom-corn. It is like a comb, over which the corn-brush is thrown, and the seeds stripped off by pulling the brush between the teeth.

Broom-han'dle Ma-chine'. A lathe with a hollow mandrel and internal cutters. The stick is

passed longitudinally through the mandrel and rounded throughout its length.

In the example the hollow mandrel has a pair of circular cutters for cutting off the rough corners of the handle; also a tapering bit oscillating on a pivot and acted on by a spring, a lever being connected with the cutter by a link, and the bit being con-

Fig. 943.



Broom-Handle Lathe

trolled by plates connected with catches, projections resting on the flanges of the cam-wheels attached to a shaft, there being, farther on the mandrel, a third beveled cutter, with its cutting-edge flatwise thereto, so that by their movements the various work is effected.

Broom-head. A clasp or cap for holding the bunch of broom-corn, so that a worn stump may be removed and fresh brush substituted. There are very many forms, among which may be cited the examples annexed, which require but little explanation.

In the upper left-hand example the broom-corn is hung over the stirrup and drawn into the cap by the screwing of the stirrup into the handle.

The next figure shows another stirrup, screw-shank, and cap arrangement.

The figure beneath the one last described has a head whose bars have prongs to enter the bunches of brush. The bars of one side open to admit the broom-corn, and are then locked in closed position.

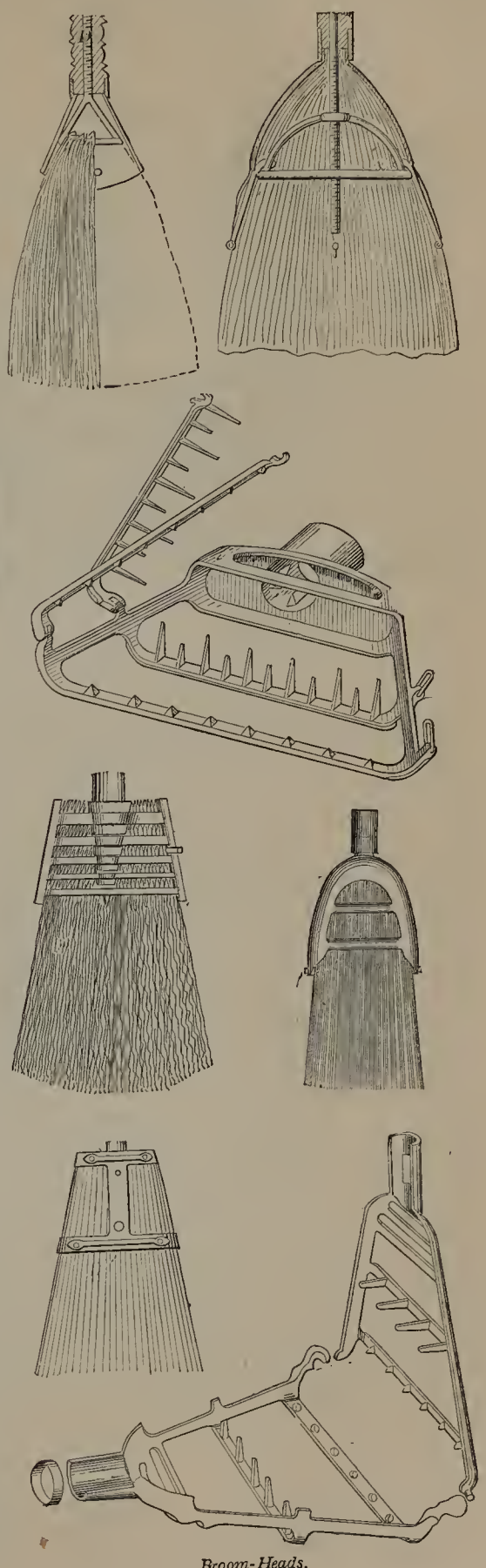
The next examples have variously shaped heads and modes of securing the contents.

The lower figure has a clasp with a pair of hinged jaws with pronged bars.

Broom-sew'ing Ma-chine'. A machine for pressing a bunch of broom-corn into shape for a broom, and sewing it in its flattened form. The broom is placed between jaws *a a*, closed by an eccentric *c*, operated by lever *b*.

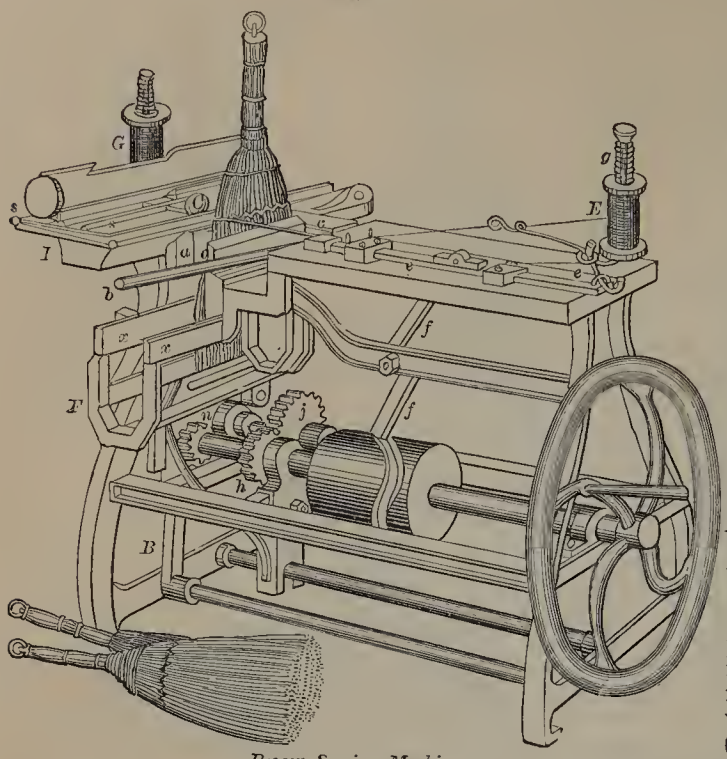
The machine being set in motion by the rotation of the shaft of the cam-wheel *A*, the cam-groove of the latter, actuating the lever *f*, forces forward the needle-bar *e*, thus driving the needle with its thread through the broom above the twine wound around the latter. The shuttle *C*, operated by lever *B*, acting on the opposite side of the broom in conjunction with the needle, forms the stitch. This being done, the reverse movement of the needle-bar withdraws the needle, the eccentric *n* lifts the jaws *a*, so that the next stroke of the needle carries the stitch below the binding-twine, the jaws being meanwhile moved along the guides *x* by means of a pawl, operated by

Fig. 944.



Broom-Heads.

Fig. 945.



Broom-Sewing Machine.

a cam *n* on a supplemental shaft moved by gears *h j*, the pawl gearing with a ratchet formed at the under side of the outermost of the jaws *a*. The next outward movement of the needle, the jaws being, of course, again lowered, carries the stitch above the binding-twine. In this manner the stitches are formed alternately above and below the binding-twine, the distance apart of the stitches corresponding, of course, to the intermittent feed given, as just described, to the jaws *a* upon their supporting-guides *x*. The needle is supplied from spool *E*, which has a tension-spring *g*.

Brough'am. (*Vehicle.*) From *brouette*, a form of fiacre invented by Dupin about 1671. A closed carriage with a single inside seat for two persons, and an elevated driver's seat. The front is glazed, and the fore-wheels turn on a short lock.

Brow-band. (*Saddlery.*) A band of a bridle, head-stall, or halter, which passes in front of the horse's forehead, and has loops at its ends, through which pass the cheek-straps.

Brown'ing. A process by which the surfaces of articles of iron acquire a shining brown luster; this may be produced by chloride of antimony.

Browning, or Bronzing Liquid. Sulphate of copper, 1 oz.; sweet spirit of nitcr, 1 oz.; water, 1 pint. Mix. In a few days it will be fit for use.

Browning for Gun-Barrels. Tinct. of mur. of iron, 1 oz.; nitric ether, 1 oz.; sulph. of copper, 4 scruples; rain-water, 1 pint. If the process is to be hurried, add 2 or 3 grains of oxymuriate of mercury.

When the barrel is finished, let it remain a short time in lime-water, to neutralize any acid which may have penetrated; then rub it well with an iron wire scratch-brush.

Another recipe is:—

Nitric ether	6 ounces.
Alcohol	1 ounce.
Sulphate of copper . .	1½ ounces.
Muriated tinct. of iron .	1½ ounces.
Tinct. of gum benzoin .	1½ ounces.
Water	3 pints.

The blue vitriol is first dissolved in the water (boiling).

Brown Pa'per. A coarse kind of wrapping-paper, which is made from unbleached material, such as junk, hemp, refuse flax, etc. It is made of various qualities, from *manilla* to *straw*.

Brown Ware. A common variety of pottery, named from its color.

Brow-post. (*Carpentry.*) A beam that goes across a building.

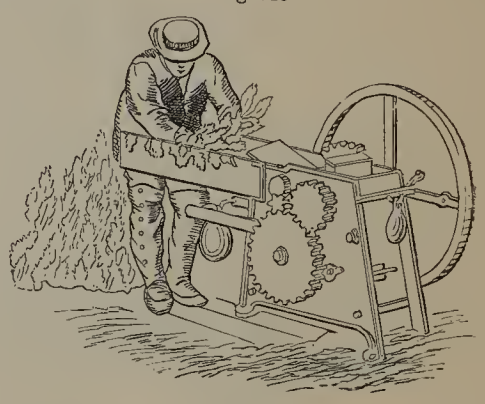
Bruis'er. A concave tool used in grinding lenses or the speculums of telescopes.

Bruis'ing. (*Leather-manufacture.*) After curried leather has been *daubed* and *dried*, it is *grained* by folding *grain*-side in, and rubbing with a *cripple*r. It is then extended and rubbed on the grain-side, which is called *bruising*.

Bruis'ing-ma-chine'. A machine for bruising rough feed to make it more palatable and digestible for stock. It is principally used in Britain in bruising prickly plants such as the furze, which is also known as *whin* or *gorse* (*Ulex Europeus*),—a prickly plant very common in the British Islands, and very nutritious when brought into a condition which does not repel the animals.

The mode of preparing it, where machinery is not accessible, is by means of the chopping-block and mallet.

Fig. 946.



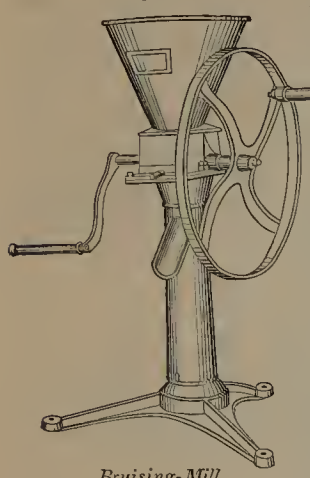
Furze-Bruising.

The illustration shows a bruising-machine with studded cylinders.

Bruis'ing-mill. (*Milling.*) A hand-mill in which grain for feed, malt for brewing, and flax-seed for pressing, are coarsely ground. It consists of two cast-iron rollers mounted on a strong frame, and so arranged that grain is carried between them and crushed more or less according to the degree to which the rollers are tightened up by the hand-screw at the end of the frame. With the hand-mill one man will crush about 2½ bushels of oats or flax-seed per hour, and two men 4 bushels. By horse or steam power it will crush from 15 to 24 bushels per hour. Of malt, from two to three times the above quantities may be ground. (Fig. 947.)

Brush. 1. An assemblage of hairs, hog's bristles, strips of whalebone, short wires, fastened to a handle, either collectively or in separate tufts.

Fig. 947.



Bruising-Mill.

The smallest kind of brushes are used in water-color, and some kinds of house, sign, and coach painting, and are called *pencils;* camel, badger, squirrel, goat, fitch, and sable hair, etc., are employed. These are made by inserting a tuft of the hairs with their roots bound together into a quill previously softened, which, on drying, serves to hold them fast; for the larger sizes, a tin tube, either round or flat, is employed.

Hogs' bristles are, however, the material principally used, the whiter and better kinds being employed for hair, tooth, clothes, and hat brushes, and also for the better classes of paint-brushes.

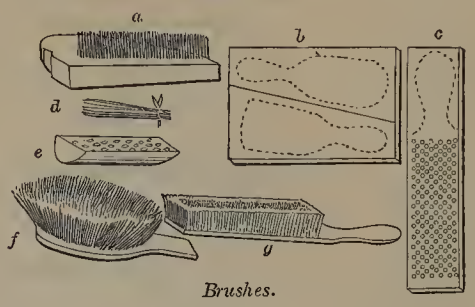
The bristles are first sorted according to color, and then, by means of a series of combs (*a*, Fig. 948), having teeth formed of needles of various sizes, and placed at different distances apart, they are assorted according to size, by employing at first the largest comb and then in succession the smaller ones, fixed to a work-table.

The paint-brush — the simplest form of brush — is made by inserting full-length bristles between two projecting prongs on the handle, and securing them by a wrapping of twine, which is afterward protected by a coating of glue mixed with red-lead. In other paint-brushes the bristles are surrounded by a metallic cap, which binds them to the handle. In large paint-brushes and painter's dusters, the handle is secured by driving its smaller end foremost into the bristles, placed within an iron cup, which binds them fast.

Hair-brooms, dusters, etc., are made by inserting tufts of bristles into a stock or head previously bored with holes for their reception. These are frequently bored angularly to the face, or the face itself is rounded so as to give the tufts an outward splay when inserted; the root-ends are first dipped into melted pitch, then bound with thread, again dipped, and then inserted with a sort of twisting motion. Brushes of this description are usually made with bristles of the full length; but where stiffness is required, as in scrubbing, hair, and other similar brushes, each tuft of bristles is doubled so as to present both ends outward; these are then cut off square and even, presenting a hard surface, especially when the doubling is made near the root-ends.

The stocks or brush-boards are cut from pieces of requisite thickness, so as to get two out of each width of board (*b*, Fig. 948). The holes are drilled through a pattern-board, to insure uniformity; this is flat for a plane-surface brush, but if the edge is to have oblique rows of bristles, a pattern bent to a corresponding obliquity is employed. *Drawing*, the next step, is performed by clamping the drilled stock to a table and passing a loop of brass wire through the first hole in the first row, inserting a tuft of bristles through the loop and drawing on the wire, so as to pull the tuft into place, when, bending the wire again, another loop is formed, and so on successively until a row is completed, when the tufts are cut off with shears to a length regulated by a gage; or, in case the bristles are short, the stock is filled previous to cutting. In Fig. 948, *c* shows a perforated brush-back, *d* a tuft ready for insertion, *f* the face of an oval brush after drawing, and *g* a brush of black bristles with an edging of white bristles, cut and finished. The drawing-wires are neatly covered with veneer to strengthen and improve the brush, and prevent the wires from scratching the hand; after which the brush is finished up with a spoke-shave and scraper, sand-papered, and varnished. In the smaller kinds of drawn brushes, such as nail and tooth brushes, the holes are sunk in narrow grooves in the stock, which are afterwards filled with a hard red cement.

Fig. 948.



Brushes.

The best sorts of brushes are *trepanned;* in this process a number of holes are drilled in the bone back either transversely or longitudinally, and a number of holes are sunk through to these from the face-side of the brush; the tufts are then drawn with strong thread or silk, and the longitudinal or transverse holes filled with plugs of bone or ivory.

Whalebone, cut into strips, and split, is used in the same manner as bristles, to form brushes, either by itself or in conjunction with bristles. In the latter case, the adulteration is soon detected by the more rapid wear and splitting of the ends of the whalebone.

In Woodbury's brush-making machine a quantity of the bristles is laid upon a comb-shaped feeder, and a steel point parts from their edge, as spread upon the apron, just enough for one bunch. A plunger comes down upon this bunch and bends it double, the two halves fitting into slots in a follower in size suited to the work in hand. A carrier then pushes about two inches of wire through the bunch at the bend, and cuts off the part thus advanced. The plunger now pushes the doubled bunch with wire down into a nut with spiral threads or rifles on the inside, at the same time giving it a twist. The effect of this motion is to wrap the wire as a spiral or screw thread around the bunch, and the twisting or gimlet motion continues so as to screw the bunch, wire and all, into the hole of the brush-stock below, giving it the firmness and solidity of a screw. Then releasing its hold and giving one revolution backward, to take the twist out of the bunch, the plunger flies up and is ready for another bunch, which it prepares and inserts by the same motions. This set of operations is completed at the rate of about 70 series per minute, thus finishing an ordinary scrubbing-brush within that time. As the holes do not pass through the wood, no back is required.

Among the varieties and parts of brushes, and the appliances concerned in their making, may be named: —

Blacking-brush.	Bristle-bunching machine.
Black-lead brush.	Bristle-cleaning machine.
Bottle-brush.	Bristle-washing machine.
Brass-finisher's brush.	Broom.
Bristle-assorting machine,	Brush-back.

Brush for cannon.
Brush-handle.
Brush-head.
Brushing-machine.
Brush-making machine.
Carpet-brush.
Carriage-brush.
Cloth-brush.
Clothes-brush.
Drawn-brush.
Dusting-brush.
Ear-brush.
Engine-brush.
Feather-brush.
Flesh-brush.
Flue-brush.
Furniture-brush.
Graining-brush.
Hair-brush.
Hair-pencil.
Harness-brush.
Hat-brush.
Hearth-brush.
Horse-brush.
Hydraulic-brush.
Irrigating-brush.
Lure.
Marking-brush.
Mechanical broom.
Nail-brush.
Paint-brush.
Paste-brush.
Revolving-brush.
Rotary-brush.
Scrubbing-brush.
Shoe-brush.
Spoke-brush.
Stock-brush.
Street-sweeping machine.
Tar-brush.
Tool-brush.
Tooth-brush.
Tube-brush.
Velvet-brush.
Whisk-brush.
Wire-brush.

2. A mop for cannon. See SPONGE.

Brush-hat. One in which the surface is continually brushed by a hand-brush, during the process of sizing, so as to bring a nap to the surface.

Brush'ing-ma-chine'. 1. (*Hat-making.*) A machine for brushing hats, to remove the dust after pouncing, or to lay the nap smoothly.

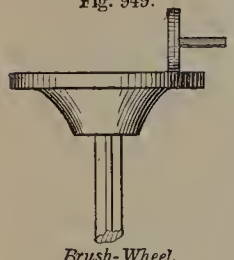
2. (*Woolen-manufacture.*) A machine used to lay the nap on cloth before *shearing*. It has a cylinder covered with brushes. For some purposes, the cloth is damped by exposure to steam, which escapes in minute jets from a copper box extending the whole width of the machine. Sometimes called a *brushing-mill*.

3. (*Flax-manufacture.*) A machine for scutching flax, in which the beaters are superseded by stiff brushes of whalebone. See SCUTCHING-MACHINE.

Brush-puller. (*Agriculture.*) A machine for pulling up brush by the roots. It sometimes consists of a mere hand-tool, with a gripper to give a firmer hold than the hand will readily afford. As a machine, it is a traveling implement with closing jaws, which seize the bushes and pull them out as the team moves on.

Brush-wheel. *a.* A wheel with bristles on its periphery, used to turn another wheel. One of the wheels being driven, communicates motion to the other by frictional contact. The contacting surface may be a brush, leather, india-rubber, cloth, or anything else which is slightly elastic and not too slippery. The relative rate of motion may be adjusted by moving the wheel whose periphery is engaged towards or from the center of the face-wheel. The motion may be communicated by contact of the peripheries of the respective wheels.

Fig. 949.



Brush-Wheel.

b. A circular brush running in a lathe, and used to polish articles, is also called a brush-wheel.

These brushes are hard or soft, and the wheels are from two to eight inches in diameter.

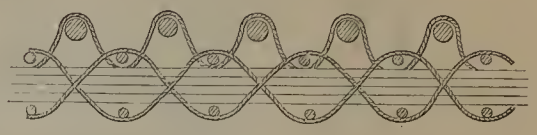
They are used with emery, putty-powder, rottenstone, crocus, rouge, etc., and other kinds of polishing-powder, with oil or dry. They are especially useful in chased, indented, carved, and open work.

The brushes are generally of bristles, but sometimes of wire.

Brus'sels Car'pet. A carpet having a heavy linen web, inclosed in worsted yarns of different colors, raised into loops to form the pattern. The ordinary Brussels carpet has an uncut pile. In the *imperial* Brussels the figure is raised above the ground and its pile is cut, but the ground is uncut.

In the illustration the small dots represent the ends of the linen weft-threads; the double waving lines the linen warp-threads; the five lines inclosed

Fig. 950.

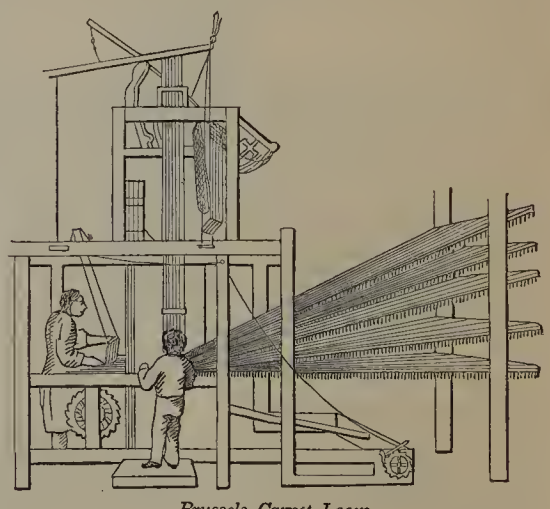


Brussels Carpet.

between the linen warp and weft represent the worsted yarn which is pulled upon to form loops over the wires, which are represented in the figure by the larger dots, and are subsequently withdrawn. The pattern is formed by bringing to the surface, at any particular spot, such one of the colored yarns as is required, and they are formed into loops by being turned over wires. As the yarns are taken up very unequally, they are not wound upon a yarn-beam, but are separately wound upon bobbins arranged on frames at the back of the loom, a small leaden weight being attached to each bobbin to give it the required tension.

In the *Brussels-carpet loom* there are as many frames as there are colors, and the number of bobbins is regulated by the width of the carpet. With $\frac{3}{4}$-yard-wide carpet there are 260 bobbins to a frame,

Fig. 951.



Brussels-Carpet Loom.

but when the carpet is one yard wide, each frame will have 344 bobbins. The warp-yarn from each bobbin is termed an *end*; this may consist of one, two, or three threads, according to the quality of the carpet. The *ends* are carried through small brass eyes, called *mails*, attached to fine cords, one eye and one end for each cord. Each cord is passed over a pulley fixed above the loom, and is fastened to a stick. For a $\frac{3}{4}$ carpet there are 1,300 *mails*, cords, and pulleys to each loom. Those cords which will raise to the surface a certain set of yarns required for one row in the pattern are bound together into a *lash*.

One *lash* is necessary for every set or row of colors that has to be drawn to the surface, and the *lashes* are taken in regular succession till the pattern is complete.

The number of lashes required will depend upon the number of weft-threads which occur in the regular recurrence of a complete pattern. If the pattern be a yard long, it may require as many as 320 *lashes*. The lashes are pulled by a boy who is called the *drawer*, in the manner of the DRAW-LOOM (which see). Like the latter, the arrangement described has been superseded to some extent by the *jacquard* attachment.

In operation, the first lash being pulled raises one fifth of the yarns, their colors being such as go to form the commencement of the pattern. A light wooden board termed a *sword* is set up on edge beneath the raised *ends*. The *lash* is let go; a round wire is inserted in the *bosom*, or opening formed by the sword, which is then withdrawn. The weaver then depresses a treadle which works the *heddles* and crosses the linen warps, and depresses all the worsted ends except those looped over the wire. The shuttle with a linen weft is then thrown; the other treadle is depressed, which crosses the warps, again locking the linen weft and raising the worsted ends. Having thrown another linen weft-thread, and driven all home against the *web* by the batten, he repeats the process, the *drawer* pulling on the second lash and so on. When a number of wires are thus employed, the ones farthest from the batten may be withdrawn and used over again. Sixty wires form a set.

In making *Wilton* or *pile carpet* the wires are flattened and have a groove on top, acting as a director for the knife which cuts the row of loops and releases the wire.

The quality of *Brussels* and *Wilton carpets* is estimated by the number of wires to the inch. The usual number for *Brussels* is nine, and for *Wilton* ten. In either fabric great care is requisite in beating up evenly, or the pattern would not match when the breadths were joined together at the sides. A bell rings when 64, 80, or 90 *lashes* have been woven, and then the weaver tests by a measure whether the required number of lashes measures ¼ of a yard. If too short, he repeats the last lash; if too long, he omits it.

As the five ends run throughout the yarn while only one of the five is taken up on an average at each *lash*, it has been attempted to dye the yarn in places, so as to make one set of ends fill the various colors of the pattern. See PRINTED CARPET.

Brus'sels Lace. *Brussels point* has the network made by the pillow and bobbins.

Brussels ground has a hexagonal mesh, formed by plaiting and twisting four flaxen threads to a perpendicular line of mesh.

Brussels wire-ground is of silk. The meshes are partly straight and partly arched.

The pattern in each case is worked on with a needle after the mesh is completed.

Bub. A substitute for yeast, employed by the distiller. Prepared by mixing meal or flour with a little yeast in a quantity of warm wort and water.

Bub'ble. The glass spirit-tube of a level.

One of the small hollow beads, or floating globes, for testing the strength of spirits by the rate at which they rise in the liquor. Now superseded by the *alcoholmeter*.

Bub'ble-tri'er. An instrument for testing the delicacy and accuracy of the tubes for holding the spirit in leveling-instruments.

The tube is charged with spirit all but a bubble of air, and is tried on its different sides to ascertain on which side the bubble moves most regularly. The stage of the *bubble-trier* has a micrometer screw for its adjustment.

Bu-cen'taur. (*Vessel.*) The state barge of Venice.

Buck. (*Masonry.*) 1. To break ore into fragments with a hammer, crusher, or grinder. This is subsequent to the operations of *spalling*, *cobbing*, and *sorting*.

2. A frame of two crotches to hold a stick while being cross-cut. See BUCK-SAW.

Buck-board. (*Vehicle.*) A plank bolted to the hind axle and to a bolster on the fore axle, being a cheap substitute for a bed, coupling, and springs.

Buck'et. 1. A vessel of wood, leather, metal, or other suitable material, provided with a handle, and adapted for containing liquids or solid materials, as in carrying or hoisting.

The ordinary wooden bucket is of pine or cedar, and holds 2½ gallons.

The bucket for hoisting is metal-bound, and sometimes is equal in capacity to a cask of 100 gallons. A *corf*.

In mining, square boxes with falling bottoms are known as *dumping*-buckets. When having sides which open when a latch is withdrawn, they are *tilting*-buckets.

On shipboard, buckets kept for emergencies in case of fire, etc., are frequently of tarred or waxed canvas or of leather. Watering-buckets for horses are, in the United States military service, made of stout, untarred canvas, and also of sole-leather, strengthened by a copper rim at top and bottom connected by side strips.

Previous to the general introduction of water-mains and fire-plugs, leathern fire-buckets were in common use. The spectators, always numerous on occasions of fire, were formed in two lines, one of which passed the full buckets from hand to hand, for supplying the engine, and the other passed the empty ones back to be replenished. Some of these relics of the past may yet be seen in old warehouses, etc.

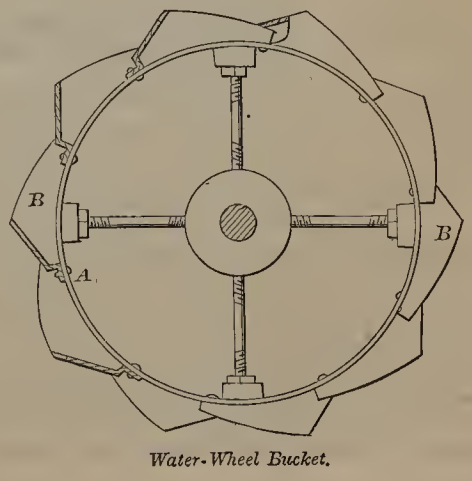
2. (*Water-wheel.*) The *vane* or *float* of a water-wheel.

The *shrouding* of a water-wheel consists of annular plates at the periphery, which form the sides of the bucket; the bucket-*ends*, in fact, but constituting a part of the *sides* of the wheel.

A *radial* bucket is one which has the bottom in a right line, continuous with the radius of the wheel.

The lower piece of a bucket is the *bottom* or *floor*.

Fig. 952.



Water-Wheel Bucket.

The outer piece is the *arm* or *wrist*. The junction of the *bottom* and *arm* is the *elbow*.

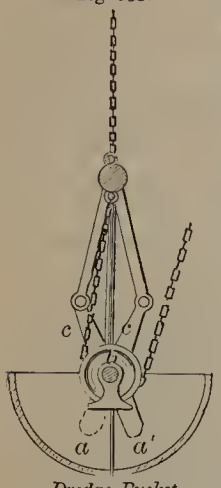
The *bucket-pitch* is a circular line passing through the elbows of the series of buckets.

In the illustration (Fig. 952), the buckets *B* are each shaped of a single piece of metal, and they are fastened consecutively on the rim *A*, which is continuous and forms the inner side of each bucket.

The buckets *B* on the left-hand side of the wheel are in section, and show the shape of the interior.

3. (*Hydraulic Engineering.*) The scoop of a dredging-machine, usually having a hinged bottom, which is closed while raising mud, etc., from the bottom, and opened to deposit the load. That illustrated is of semi-cylindrical shape, and formed in two sections, *a a'*. These are separated when the bucket is lowered down into the mud, and drawn together by the toggle-levers *c c* at the moment of raising.

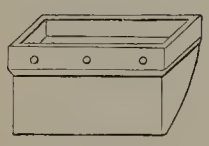
Fig. 953.



Dredge-Bucket.

4. A cup of sheet-metal, or

Fig. 954.



Elevator-Bucket.

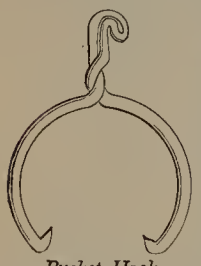
one having a metallic mouth, forming one of a series fixed to the endless band of a grain-elevator. The grain is scooped up at the lowest position of the bucket and discharged on passing the highest, as in a chain elevator-bucket pump.

5. (*Nautical.*) A globe of hoops covered with canvas, used as a recall-signal for whale-boats.

Buck'et-en'gine. (*Hydraulic Engineering.*) A machine to utilize a stream of water which has considerable fall and but moderate quantity. It consists of a series of buckets attached to an endless chain which runs over sprocket-wheels, from one or both of which power is obtained. The water flows into each bucket after passing the summit, and is discharged as each bucket reaches the lowest part of its course.

Buck'et-hook. (*Husbandry.*) A device for holding a bucket against a tree while catching sugar-maple sap. It may be driven into the tree, or may have a pair of expansible arms which embrace the tree.

Fig. 955.



Bucket-Hook.

Buck'et-mak'ing Ma-chine'. Several machines may be included under this general title.

A lathe whose hollow chuck holds the staves, which are embraced by a truss-hoop, while the inside is turned out and the rim turned off smoothly. Being then turned end about, and put upon a conico-frustal chuck, the outside is turned smooth, the lower edge turned off, and the croze made.

The piece to form the bottom is fastened to a face-plate, and turned off smooth and circular, the edge being feathered to fit the croze.

Another form of bucket-machine is one which cuts up a conical frustum of wood, so that a series of annular conical pieces are cut out of the solid, the pieces forming a nest of bucket-sides fitting within each other, and only minus the wood which was removed in making the saw-kerf.

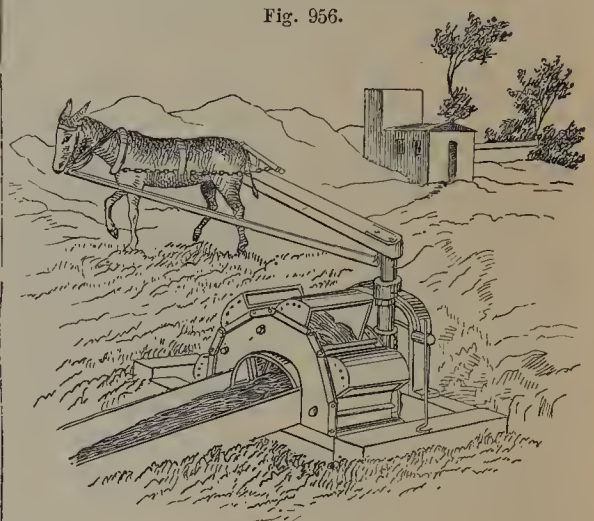
The block is placed upon a table whose angle with the horizontal is such as to make vertical that side of the bucket-block on which the band-saw is working.

Buck'et-valve. (*Steam-engine.*) The valve on the top of the *air-pump* bucket. It rises as the bucket plunges into the water in the cistern beneath, and closes as the said bucket rises to discharge its load through the *delivery-valve*.

In marine engines a flat metallic plate governs the passage between the air-pump and condenser.

Buck'et-wheel. (*Hydraulic Engineering.*) A very ancient form of water-raising device, having a

Fig. 956.



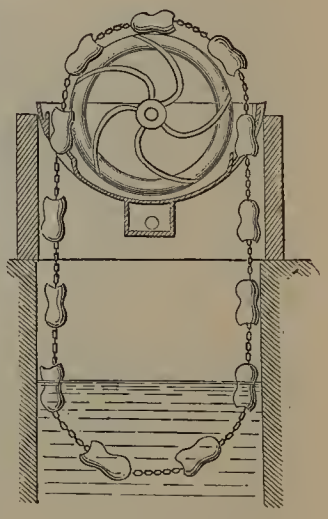
Bucket-Wheel.

wheel over which passes a rope having pots or buckets which dip into the water of the well and discharge at the surface.

In another form the pots are attached to the wheel and dip the water of a river, which they discharge into an elevated trough. See NORIA.

The illustration shows a wheel as used in Syria, India, Egypt, etc., but made in modern style by the Giours. The buckets are made of galvanized iron, and an ass walking 1½ miles an hour — Syrian gait — will raise 3,120 gallons per hour from a depth of 20 feet.

Fig. 957.



Bucket-Wheel.

In one form of water-elevator the buckets are small, and constitute links in a chain; the more common form is disks or buttons on a chain rising through a tube and thus carrying up the water.

The bucket-wheel is used in grain-elevators. See BUCKET. Also in *Carburetors*.

Buck'ing. 1. (*Cotton-manufacture.*) Soaking cloth in lye, as a part of the process of bleaching, alternating with *crofting*,

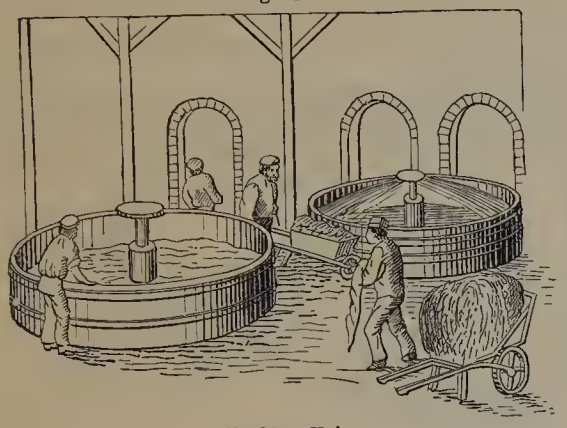
or exposing on the grass to air and light. See BUCKING-KIER.

2. (*Mining.*) Breaking up the ore by hammers. The tool is called the *bucking-iron*, and the bench is the *bucking-plate*.

Buck'ing-i'ron. (*Mining.*) The miner's hammer, used in breaking up masses of ore.

Buck'ing-keir. (*Cotton-manufacture.*) Linen or cotton cloth is cleansed of the dirt and grease contracted in spinning and weaving, by boiling it with lime in a pan which is heated below. The

Fig. 958.



Bucking-Keir.

goods rest on a false bottom, and the pressure of the steam evolved raises the water in the central column and ejects it from the edge of the circular cap in a stream upon the upper surface of the goods, through which it filters, to be again discharged as before.

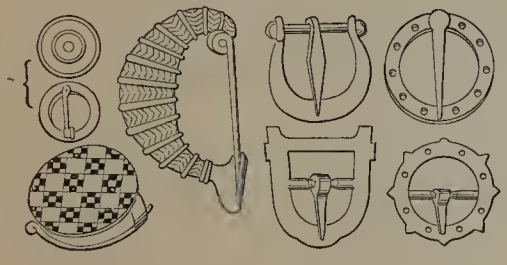
Buck'ing-plate. (*Mining.*) The miner's table on which ore is broken.

Buck'le. 1. (*Saddlery, etc.*) A device with a frame and tongue for securing straps, etc.

Buckles of brass, having circular rims and a tongue, are found in the British barrows or tumuli.

The annexed figure represents Roman bronze buckles now in the British Museum. They were worn by

Fig. 959.



Roman Buckles (Bronze).

women and men, to fasten their scarfs, shawls, cloaks, belts, etc. We read of them in Homer, Euripides, Herodotus, and elsewhere. See BROOCH.

Shoe-buckles were introduced into England during the reign of Charles II. (1670). These, as well as knee-buckles, were generally made of silver, — sometimes of gold, — adorned with precious stones, but are now disused, except as ceremonial or uniform dresses in some parts of Europe.

The principal use of buckles is for fastening the different straps of harness and horse equipments, for which purpose immense numbers are made, forming a considerable branch of trade, of which Birmingham is the metropolis.

Much the greater part of harness-buckles are either japanned or plated, the former being used for wagon, cart, and the commoner kinds of harness generally; and the latter for carriage-harness.

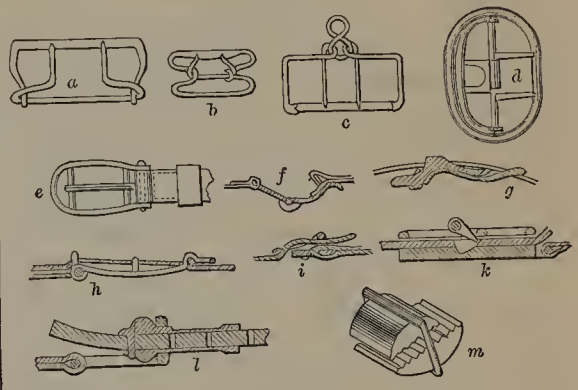
The plating material is usually brass, though many silver-plated buckles are manufactured.

Buckles are also made of bright malleable iron, and of blued iron; the latter are the kind employed in horse equipments for the cavalry in the United States Service.

Buckles are divided into bar-buckles and roller-buckles, the only difference being that the latter have a thin metallic tube around the bar opposite the tongue, which, by its revolution, facilitates the passage of the strap.

a (Fig. 960) has a wire passed through the ends of the loop and bent ends to form tongues. *b* has a bent wire embracing the waist of the loop. *c*, the recurved ends of the loop form the tongue. *d* has a tongue and pressure-bar on one crossbar. *e* is a tug-

Fig. 960.



Buckles.

buckle. *f* is a buckle in which the strap is pinched between a pivoted bar and the lip of the frame. In *g* the strap is pinched between the two parts of the frame, which are pivoted together. *h* has a number of projections, which fit corresponding holes in the strap. *i* is a skate-strap buckle, in which the tongue can be loosened from the strap by lifting the rear end of the buckle. *k* is a tug-buckle, in which the tongue is vibrated by means of a cam. *l* has a pair of metallic jaws and a tongue extending across them. *m* has a pair of serrated-faced blocks which are pinched together by the strain on the strap.

2. A permanent distortion or *kink* in a saw-blade, or a bulge which mars the flatness of a sheet-metal plate.

3. (*Saw.*) The iron loop by which a mill-saw is attached to the straining-frame or *sash*.

Buck'le-chape. (*Saddlery.*) The part by which the buckle is secured to the band.

Buck'led Plates. (*Building.*) A form of iron plates for flooring, having a slight convexity in the middle and a flat rim round the edge, called the *fillet*. They are usually square or oblong, and are laid upon iron beams or girders, convexity upward.

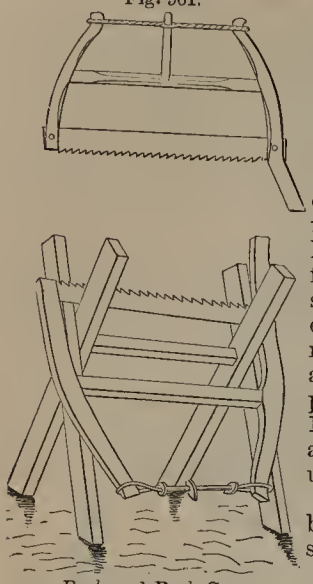
Buck'ler. (*Nautical.*) *a.* A block of wood made to fit in the hawse-hole, or hole in the half-ports, when at sea.

b. The lower half of a divided port lid or shutter.

Buck'ram. (*Fabric.*) A coarse fabric of linen or hemp, stiffened with glue, and placed in coats and other garments to hold them in shape.

This was not the material worn by Falstaff's "two rogues in *buckram* suits." See BARRACAN.

Fig. 961.



Buck and Buck-Saw.

Buck-saw. A frame-saw with one extended bar to form a handle, and adapted to a nearly vertical motion, in cross-cutting wood held by a saw-buck.

Buck'shot. A kind of leaden shot, larger than swan-shot, used in hunting large game, and formerly for the military service. Those formerly employed for making musket-cartridges weigh about 160 or 170 to the pound. 15 (sometimes 12), or a caliber .69 ball and 3 buckshot, were put up in a cartridge.

They are usually made by molding or compression.

Buck'skin. A species of soft leather, usually of yellow or grayish hue, originally (as its name imports) prepared by treating deer-skins in a peculiar way; it is now, however, mostly prepared from sheepskins. There are two processes for dressing skins to give the soft character which is admired in buckskin; one is by oil, and the other by *brains*. The latter more nearly resembles the Indian mode, and both of them require a great deal of manipulation. As to the former, the skins are limed, then worked out on the beam; then they are milled, straits-oil being mostly used, in the proportion of seven to fifteen gallons to 100 skins, according to size. The surplus oil runs through the mill into tubs of water below, whence the oil and water are pumped into a tank in which a certain amount of oil of vitriol is placed; this causes the oil to rise to the top, whence it runs off into barrels, and is known as sod-oil, being used for stuffing and dressing calfskins. The skins are then worked over the beam again, this operation being known as "scudding." The skins are next dried; then they are put into a lye consisting of from fifteen to forty pounds of soda-ash for 100 skins; this takes out the animal oil, which rises to the top and is skimmed off for sod-oil. They are scoured and dried repeatedly, and then undergo the operation of staking; the last operation is the finishing, which is done first on a pumice-wheel and then on an emery-wheel. The skins are then ready to go to the cutting-shop.

By the other plan, the skins are *grained*, *brained*, and *smoked*. The skin is soaked till soft, the hair and cuticle curried off, beamed, stretched, and broken in drying. It is then soaked in brains dissolved in warm water, which makes the skin thick and spongy. It is carefully stretched and worked, and is tested by gathering into a sack-form and inflating, when pressure will drive off the contained water in a spray. It is now wrung, stretched, rubbed, and hung in a smoke. A slight tanning in willow-bark ooze sometimes follows.

Buck-wag'on. (*Vehicle.*) A rude wagon formed of a single board resting on the axletrees, and forming by its elasticity a spring seat for the driver.

Buck'wheat Hull'er. A form of mill, or an ordinary grinding-mill with a particular *dress* and *set* of the stones, adapted to remove the hull from the grains of buckwheat, preparatory to grinding the farinaceous portion into flour.

Bud'ding-knife. (*Agriculture.*) A knife with a convex blade and flattened handle, used for cutting the scion, making the incision, and inserting buds beneath the bark of fruit-trees. A spear-shaped slip of ivory at the hilt is used for loosening the bark from the wood.

Bud'dle. (*Mining.*) An oblong inclined vat in which stamped ore is exposed to the action of running water, in order that the lighter portions may be washed away while the heavier are retained. Several different descriptions of apparatus are called by this name as generic.

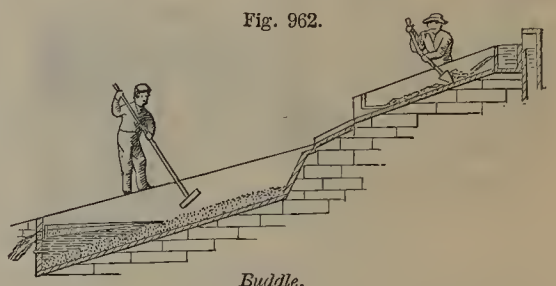
The *trunk-buddle*, or *German chest*. See TRUNK.

The *stirring-buddle*, consisting of a trough and settling-tank.

The *nicking-buddle* or *sleeping-table*, *buddle-hole* or *sluice-pit*.

Buddles of different construction are known as *flat*, *round*, *hand*, *rotating*, *concave*. Many of the contrivances for gold-washing, used in California

Fig. 962.



Buddle.

and known by technical names, may be called buddles. The *rockers*, *long-toms*, and *sluices* act in this manner. The buddle represented is used in Cornwall, England.

The ore is spread over an inclined board, and a divided stream of water directed upon it, so as to gradually carry it down to a lower level, where the inclination is not so great. The quantity of water is regulated by the roughness of the ore, and may be at the maximum as much as would run through a circular aperture $1\frac{1}{2}$ inches in diameter, down to an amount equal to one tenth of that quantity. The richer and heavier ores subside first, and the lighter portions are carried farther on. The contents of the buddle are then separated into three or four qualities, according to their proximity to the head of the buddle.

The various lots are again *buddled*, or *tozed*, or subjected to the action of the *keeve* or *jigging* machine.

Bud'dling. (*Mining.*) Separating the ore from the refuse in an inclined trough or cistern through which water flows. See BUDDLE.

Bude-light. Invented by Mr. Gurney of Bude, Cornwall, England.

It consists of an oil or gas burner, supplied with a jet of oxygen gas, by which the brilliancy of the flame is increased.

In the Argand form of burner the oxygen gas is supplied up the central tube.

Budge-bar'rel. (*Ordnance.*) A small copper-bound barrel having only one head, its mouth being closed by a leathern bag with a cap and draw-string. It is used for supplying the guns of forts and siege-batteries with cartridges from the magazine.

Bud'ge-ro. (*Boat.*) A large pleasure-boat used on the Ganges.

Bud'get. (*Tiling.*) A pocket used by tilers for holding the nails in lathing for tiling.

Buff. A polishing leather.

A slip, lap, or wheel covered with leather and

used for polishing. So called, as the kind of leather used was buffalo, was dressed with oil or brains, and had a soft and fuzzy surface. See BUFF-LEATHER.

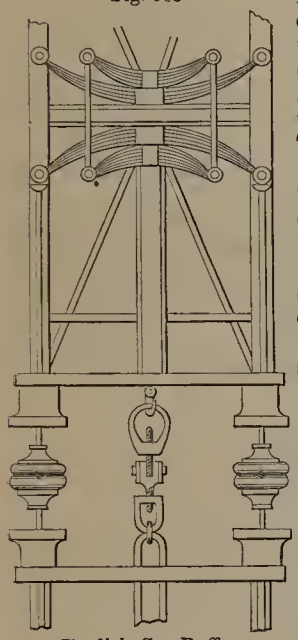
Buf'fa-lo. (*Cotton-manufacture.*) A hamper of buffalo-leather used in a factory to convey bobbins from the *throstle*.

Buf'fer. An elastic device or fender for deadening the shock caused by the impingement of one object against another.

A fender or resilient pad or block, placed on the end of a sill-piece of a car-bed to moderate the concussion of colliding cars. According to the construction and application, it assumes a specific name; and the parts involved are also distinguished with this word as an affix, e. g., —

The *buffer bar* or *beam* is attached to the framework of the car, and carries the *buffer-box*, in which is the *buffer-rod*, on whose end is the *buffer-disk*; the latter receives the impact, which is resisted by the *buffer-spring*, inclosed in the box.

Fig. 963.



English Car-Buffers.

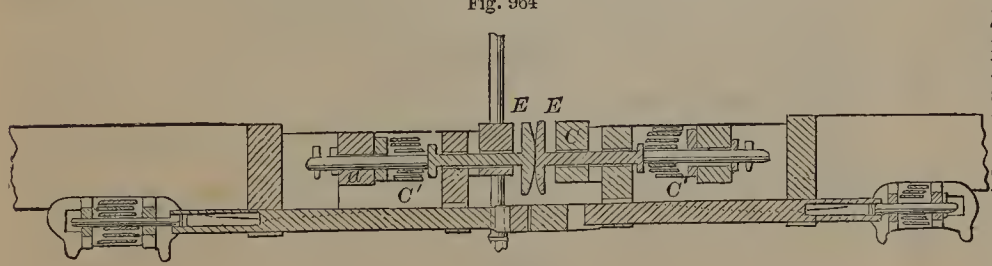
The buffers in use on English railways consist of disks of metal or wood which project from the ends of the carriages, and are commonly covered with cushions of leather. The disks are attached to iron rods placed underneath the frame of the carriage, and as they are pressed inward by the contact of the adjoining carriage, act against the ends of elliptic springs, which lessen the jar resulting from the contact. The aim of the English mode of coupling is to bring the whole train to the condition of an object whose unyielding sections have a cartilaginous articulation, which permits a certain degree of flexure, extension, and compression at the joints.

Another form is a short spiral spring covered with leather and having a disk at the end, placed at the end of each of the main side-timbers of the car-frame.

A third form has a central buffer with a shaft acting upon a spiral spring beneath the carriage-body.

In the example, the buffer-disks *E E* are on rods having shoulders which impinge upon coiled plate-springs *C*. Beneath the car-beds are seen the springs of the car-coupling.

Fig. 964



Car-Buffer.

In a fourth, the shaft acts upon a piston in an air-cylinder, the spring being pneumatic.

There are various modifications.

The *buffers* sometimes take the form of elastic cushions of leather, stuffed with horse-hair; or of disks or blocks of vulcanized rubber.

Buf'fer-spring. That which gives resiliency to the buffer, and enables it to moderate the jar incident to the contact of two cars.

The *buffer and draw spring* is effective both as to colliding contact and also as to the drawing apart in starting or increasing speed.

Buf'fing and Pol'ish-ing Ma-chine'. One having a wheel covered with what is technically known as buff-leather, though not usually made of buffalo-hide. The leather holds the polishing material, crocus, rouge, or what not. Buffing has come to mean polishing, from the derived name of the material which is used in applying the polishing material.

Buff-leather. A strong oil-leather prepared from the hide of the buffalo, elk, or ox. It is so named from the *buffe*, or wild bull, of Poland and Hungary. Formerly it was largely used for armor. It was said to be pistol-shot proof, and capable of turning the edge of a sword. It was tanned soft and white. Its place is now filled by the leather of cow-skins for a common, and of the American buffalo (*bison*) for a superior, article.

It is yet much used in the saber, knapsack, and cartridge-box belts of European armies.

The buffers and buff-wheels of the cutler, lapidary, and polisher were originally covered with the said *buff*-leather, and some are yet.

A thick, tough, felted material of which belts were made was formerly commonly known in the military service as *buff*, probably from its yellow color when not pipe-clayed; and armorers' buff-sticks, etc., are generally covered with pieces from old belts. It was an excellent material for this purpose.

Buff-stick. (*Polishing.*) A strip of wood covered with buff-leather charged with polishing-powder.

Buff-wheel. (*Polishing.*) A wheel of wood or of other material, covered with leather, and used in polishing metals, glass, etc. The surface is plied with material of coarse or fine quality, according to the character and condition of the work, one buff-wheel always having its own grade of polishing-powder, be it *emery*, *rotten-stone*, *tripoli*, *crocus*, *rouge*, *putty-powder*, etc.

Bug'ga-low. (*Vessel.*) An East India coasting-vessel with one mast and a lateen sail.

The *buggarah* is an Arab vessel of the Persian Gulf. The *bugis*, a prahu or boat trading between Singapore and the islands of the Indian Archipelago.

The *bujrah* is a flat-bottomed Ganges boat with cabins.

Bug'gy. (*Vehicle.*) A light four-wheeled vehicle, having a single seat. The top, when it has one, is of the *calash* kind. In this case it is commonly known as a *top*-buggy.

Bug'gy-boat. One having a provision for the attachment of wheels, so as to be converted into a land vehicle.

It was invented and used by Sir Samuel Ben-

tham, in Russia, 1781, and was patented by him. He afterwards extended the idea to baggage-wagons. A flexible boat of connected sections was also used by him to convey the Empress Catharine down the Dneiper, and was called by him the "Vermicular." The idea has been lately revived on the Thames, the boat being called the "Conneetor." Bentham's boat had six sections, drew six inches of water when loaded, and was rowed by 124 oarsmen. No space of more than an inch was to be found between the sections during flexion of the worm-like vessel. The vessel was fitted up with cabins and many eonveniences.

Bug'gy-cul'ti-va'tor. (*Agriculture.*) One having wheels and a seat so that the person may ride. See CULTIVATOR.

Bug'gy-plow. One having usually several plows attached to a single frame, and having a seat for the plowman, who rides and drives. See GANG-PLOW.

Bug'gy-top. (*Vehicle.*) The ealash top of the single-seated vehicle known as a buggy. In many of these carriages it is now made shifting, so that it may be entirely detaehed from the frame of the seat and eonstitute the vehiele an *open* buggy. In other forms the *top rail* only of the seat is shifting.

Bu'gle. 1. (*Music.*) A brass wind-instrument of the trumpet kind.

2. A long, slender glass bead; sometimes arranged in ornamental forms and attached to various articles of ladies' wearing-apparel. *Wampum*, whieh formerly served as a eirculating medium among the North American Indians, was composed of beads of this kind made from the interior parts of clam-shells, by rubbing pieees of the shell into the required shape upon a hard stone, drilling a longitudinal hole, and polishing by frietion. Those formed from the bluish-biaek portions of the shell were twice the value of the white ones.

The ancient Egyptians made many kinds of beads. Ladies are represented stringing them; a purse has been found knitted with small glass bugles.

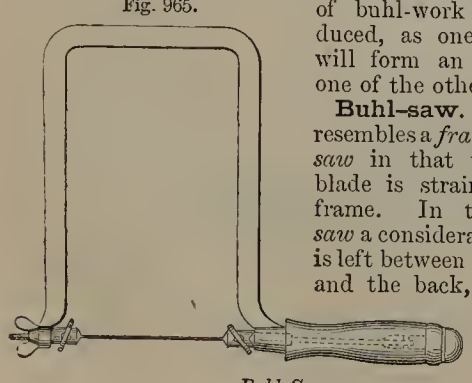
Buhl. The name is derived from André Buhl, an Italian who was eelebrated in France, in the reign of Louis XIV., for making artistic work in dark-colored tortoise-shell or wood, inlaid with brass and ornamented with the graver.

The term is now more general, and includes work in contrasted materials, inlaid with the saw.

Reisner preferred wood, and his productions were known as *Reisner-work*.

Veneers or thin plates of the substances are glued to the opposite sides of a sheet of paper; another sheet is pasted on one outside surface, and on this the design is traced. A fine frame-saw called a *buhl-saw* is made to follow the traeing, cutting through both thicknesses. The two layers are then separated, and two pieces of buhl-work are produced, as one of each will form an inlay to one of the other.

Fig. 965.



Buhl-Saw.

Buhl-saw. This saw resembles a *frame* or *bow saw* in that the thin blade is strained in a frame. In the *buhl-saw* a considerable space is left between the blade and the back, in order that the latter may avoid the angle of large works.

Buhr. A coarse, flinty, eavernous stone, whose cellular texture makes it highly suitable for mill-stones.

France, Sardinia, and Germany yield the *buhr-stone*.

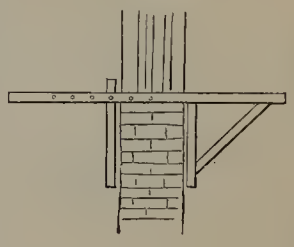
The separate bloeks which are hooped together to form a buhr-stone are known as *panes*.

The French buhrs are from a quarry near Paris, where the stratum is about three millstones thick. It is a porous silieious stone of great hardness.

Buhr, Me-tal'lic. A grinding-plate of metal, made as a substitute for the real *buhr*-stone, and used for some coarse work, such as grinding corn for stoek.

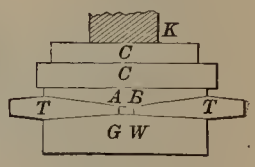
Build'er's Jack. A kind of seaffold which is supported on a window-sill and against the wall, and extends outwardly, to enable a workman to stand outside while repairing or painting.

Fig. 966.



Builder's Jack.

Fig. 967.



Building-Block.

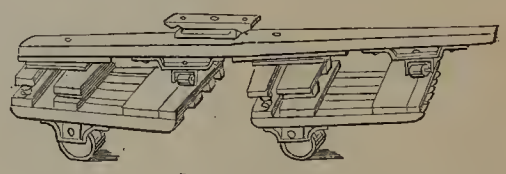
Build'ing-block. (*Shipbuilding.*) One of the temporary struetures resting upon the *slip*, and supporting the keel of a ship while building.

They consist of bloeks of timber so arranged as to be removable by knocking out the key-pieces or templets.

C C, caps.
A B, angle-bloek, shod with iron.
T T, wedges ealled *templets*.
G W, groundway.
K, keel.

Build'ing-mov'er. A heavy truck on rollers or wide track-wheel, used in moving houses. In the example, the building rests on a cross bolster, which

Fig. 968.



Building-Mover.

is supported by two trucks with three rollers each. In turning, rollers journaled beneath the bolster traverse ways upon the trucks.

Build'ing-slip. (*Shipwrighting.*) A yard prepared for shipbuilding. See LAUNCH; HYDRAULIC SLIP; SLIP-DOCK.

Built-beam. (*Carpentry.*) A compound beam made up of a number of planks, or thin, deep beams, laid parallel and seeured together.

Built-rib. (*Carpentry.*) An arched beam made of parallel plank laid edgewise and bolted together. See ARCHED BEAM; RIB.

Built-up. Said of masts made of pieees and hooped; and of cannon having an inner core and outer reïnforcements.

Buke-mus'lin. (*Fabric.*) A plain, clear kind of muslin, woven for working in the tambour and

for ladies' dresses. (SIMMONDS.) Generally written *book*-muslin.

Bulge, Bilge, or Bouge. 1. (*Coopering.*) The swell of a cask, principally in the middle.

2. (*Shipbuilding.*) The flat portion of a ship's bottom. See BILGE.

Bulk'head. (*Shipwrighting.*) A partition in a ship which divides the interior space into compartments. In wooden vessels they are made of timber, and in ships of war are so arranged as to be easily removed in preparing for action, etc. In iron vessels they are formed by plates riveted to the ribs or frames, both on the sides and bottom, each bulkhead making a complete transverse section of the vessel, and the whole being so secured as to prevent water passing from one side to the other. Several of these, being introduced, divide the vessel into water-tight compartments.

The bulkheads affording the greatest protection are those placed a few feet respectively from the stem and stern; the forward one checking the water that would enter through a damaged stem, and the after one averting the danger of any accident that might arise to the stern-post or rudder-braces, or to the tube of the shafts of screw-vessels. The water received into these small compartments would very slightly impede the way of the ship by throwing her out of trim, as the quantity they would contain would be comparatively trifling. The bulkheads more amidships assist in strengthening the vessel, and prevent fire spreading beyond the compartment in which it commenced. In case of a leak, they confine the water to that compartment where it entered.

Water-tight bulkheads have for ages been in use in China, but have only been generally introduced into this country since iron ships have been used; they are now generally employed in iron vessels, and their adoption has become a law and is enforced in England, under the regulations of their Board of Trade; in small vessels they can only be used transversely, but in larger ones they may be applied longitudinally, and are so employed in the "Great Eastern," or were before she was refitted to adapt her for the great work of laying the submarine cables of the world.

The ship "Terror," Commander Back, fitted with bulkheads for Arctic service in 1835, came home with the after section full of water.

Bull-dog. (Fr. *torchis.*) (*Metal-working.*) A refractory material used as a lining for the boshes of puddling or smelting furnaces. It is a decomposed protosilicate of iron.

Bul'len. The awn or chaff from flax or hemp.

Bul'len-nail. An upholsterer's nail, with a round head, a short shank, turned and lacquered.

Bul'let. (From the French *boulet*, diminutive of *boule*, a ball.) A small projectile for fire-arms.

The use of round bullets dates back to the time when gunpowder was first used in ordnance. Bullets are now usually cylindrical, with conical or conoidal points.

In 1418, four thousand bullets were ordered to be made of stone from the quarries of Maidstone, England. These were probably for cannon, as were the iron ones mentioned in Ryder's "Fœdera," 1550.

The trajectory of a bullet is the line described by its center on its passage through the air. It would be a parabolic curve in a vacuum, but the resistance of the atmosphere greatly modifies this and reduces the range, so that a 24-pdr. cannon-ball, fired at an angle of 45°, with an initial velocity of 1,400 feet per second, ranges only some 2,100 yards instead of more than 20,000, as it would do if the atmosphere offered no resistance.

The actual velocity of the smooth-bore musket round ball, weighing 412 grains, with a charge of 110 grains powder, at the time of leaving the gun, has been found to be 1,500 feet per second, and that of the elongated ball, cal. .58 of an inch, with 60 grains of powder, 963 feet; but though the latter has so much less velocity at the time of leaving the gun, its range is at least equal and its accuracy far superior.

The greater accuracy of the rifle is due to the fact that the rotary motion given the bullet by the spiral grooves of the gun keeps it always point foremost, and that the bullet is caused to completely fill the bore so that it leaves it in a line with the axis of the piece, which rarely happens in a smooth-bore gun, owing to the difference in diameter between the bullet and the bore.

The rifle was introduced by Koller, a gunsmith

Fig. 969.

Bullets.

of Nuremberg, about the beginning of the 16th century, and the increased accuracy given by this species of arm was soon appreciated; and from the fact of a troop of horse known as Carabins having been armed with them, the weapon itself was subsequently called carbine.

The round ball, however, still held its place until very recently, both for rifled and smooth-bore guns; and it was not until the wars of the French in Algeria, subsequent to 1830, that experiments on an extended scale were made as to the practicability of using that form of projectile, the pointed and elongated, which both mathematics and common-sense showed to be best adapted to both accuracy and long range.

Among the first of the improved balls was the Brunswick (*a*, Fig. 969), which had a circumferential belt, and was adapted for a two-grooved rifle. *b b* is the Delvigne, adapted for a sub-caliber powder-chamber, and resting by an annular shoulder upon a wooden sabot. It had a patch of greased serge. Minie and Thouvenin introduced an elongated bullet with a cylindrical grooved body and a conical point. This had a greased paper patch, and was expanded to fill the grooves by being driven down upon a *tige* in the breech of the gun. This was adopted in the French service in 1846. Delvigne subsequently patented an elongated bullet with a recessed base which he called the *cylindro-ogival*.

Minie, in 1847, produced the well-known bullet *c*, in which the *tige* was dispensed with, and the bullet expanded by the explosive force of the powder in the cup, which was inserted into a frusto-conical cavity in the base of the bullet. The English substituted a conoidal wooden plug in their Enfield-rifle bullet *d*.

In 1856, after a series of experiments by the Ordnance Department, an elongated bullet *e*, with a cavity, was adopted for the United States army. The diameter is .577 of an inch, that of the arm for which it is intended being .58 of an inch. Two varieties were made, both being precisely similar on the exterior, but differing in the size of the cavity; that for the rifle-musket weighing 500 grains, and the other for the pistol-carbine but 450 grains.

f f is the bullet of Thirouse, a French artillery officer. It is composed of lead backed by a sabot of wood with three circular grooves near its base. The Nesler ball *g* was intended for a smooth-bore.

Of the other bullets in Fig. 969, some are celebrated on account of the ingenuity or success of their inventors, others as having been adopted by different governments.

h is the American conoidal pointed bullet.

i, the Colt, with a rabbet for the cartridge capsule.

j, the American "picket," with a hemispherical base.

k k, Haycock's Canadian bullet, with a conoidal point and a conical base.

l, Mangeot's bullet with a conoidal point, hemispherical base, and two circular grooves.

m, the Prussian needle-gun bullet.

n, Norton elongated percussion rifle-shell, fitted with wooden plug (1830).

o, Gardiner's explosive shell-bullet, cast around a thin shell of copper attached to a mandrel, which is afterwards withdrawn, leaving a fuse-hole in the rear through which the charge is exploded in about 1¼ seconds.

oo is a Spanish bullet containing a charge of powder and a fulminate.

p is the Swiss federal bullet.

p p, the Swiss Wurstemberger bullet.

q and *q* are views of the Jacob's bullet and shell.

r and *r* are views of the Peter's ball, having an interior tige; one view shows it distended and battered.

s is the Belgian bullet.

t, Pritchell's bullet.

u, Mangeot's bullet.

v v, Austrian bullets.

w w, Deane and Adams's bullets, with tails.

x, English bullet, with wad.

y, Sardinian bullet.

z, Beckwith's bullet.

a a, steel-pointed bullet.

b b, the Charrin bullet, with zinc or steel point.

c c, *c c*, Tamissier's steel-pointed bullet; one view showing it intact, and the other after compression in the grooves of the rifle.

d d, the Saxon bullet.

e e, the Baden modification of the Minie, with tinned iron cup.

f f, Wilkinson's bullet.

g g, Whitworth's hexagonal bullet.

h h, Lancaster's bullet.

i i, Mefford's sub-caliber bullet, with spiral grooves on the shoulder to impart rotation.

j j, McMurtry's bullet, with spiral grooves.

k k, Williams's bullet, with a headed tige to expand a rounding disk at the base.

l l, Dibble's bullet, with a recess for the powder.

m m, Shaler's triple bullet, the pieces of which are intended to diverge after leaving the muzzle.

n n, Maduell's bullet, which is built up of interlocking portions, which part as they leave the capsule and muzzle.

q q, Shocks's perforated bullet, with a sabot in the rear.

r r, Hope's bullet, with a bent tail to direct it in a curved path.

s s, Matteson's bullet, with spiral openings through it.

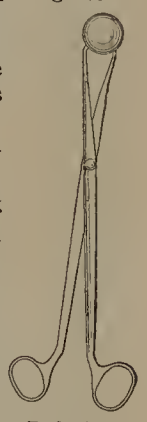
The following table shows the number of spherical leaden balls in a pound, from 1$\frac{5}{16}$ to .237 of an inch diameter:—

Diam.	No.	Diam.	No.	Diam.	No.	Diam.	No.	Diam.	No.
Inch.		Inch.		Inch.		Inch.		Inch.	
1.67	1	.71	13	.488	40	.329	130	.265	250
1.326	2	.693	14	.469	45	.321	140	.262	260
1.157	3	.677	15	.453	50	.314	150	.259	270
1.051	4	.662	16	.426	60	.307	160	.256	280
.977	5	.65	17	.405	70	.301	170	.252	290
.919	6	.637	18	.395	75	.295	180	.249	300
.873	7	.625	19	.388	80	.29	190	.247	310
.835	8	.615	20	.375	88	.285	200	.244	320
.802	9	.57	25	.372	90	.281	210	.242	330
.775	10	.537	30	.359	100	.276	220	.239	340
.75	11	.51	35	.348	110	.272	230	.237	350
.73	12	.505	36	.338	120	.268	240		

Bul'let-com'pass-es. A pair of scribing compasses with a bullet on the end of one leg to set in a hole. *Cone-compasses, Club-compasses.*

Bul'let-ex-tract'or. A pair of pinchers with projecting claws, adapted to imbed themselves in a bullet so as to draw it from its bed and extract it. When closed, these form a smooth, blunt surface, like a probe, and are opened against the bullet so as to spread apart the vessels which might oppose the retraction.

Fig. 970.



Bullet-Extractor.

Bul'let-hook. A hook-ended tool for extracting bullets.

An iron bullet-hook was disinterred at Pompeii in 1819 by Dr. Savenko, of St. Petersburg. It was in company with a number of other surgical instruments. See PROBE.

Bul'let-la'dle. One for melting lead to run bullets. It is usually a hemispherical ladle with a spout, but in one case the ladle has a hole in the bottom guarded by a spring plug and operated by a trigger on the handle; in another case a part of the ladle is covered, and the lead thus flows out at a guarded opening which keeps back the dross of oxide.

Bul'let-mak'ing Ma-chine. Leaden bullets, as well for the military service as for other purposes, were formerly all made by casting.

The most common form of bullet-mold, where

large numbers of bullets were required, was precisely like the common bullet-mold, but casting four, six, or more bullets. The gates were afterward cut off and the bullet trimmed by hand. The whole process was slow, and required a comparatively large number of hands.

To increase the rapidity of fabrication, revolving bullet-molds were tried, consisting of a cylindrical ring, to which revolution was imparted by a hand-crank and gearing, the molten lead being fed to the mold during its revolution; the gates were cut by a knife attached to the mold at the same operation; when full, the mold was opened and the bullets discharged, after which the mold was clamped shut again and the operation recommenced. These contrivances were ingenious, but were very liable to get out of order.

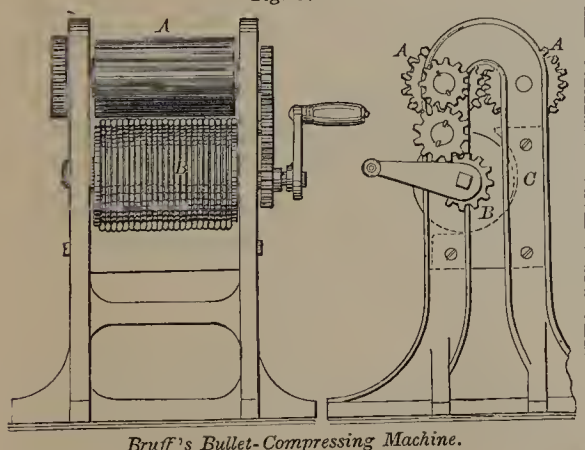
In 1857, De Zeng invented a mold for elongated bullets, constructed very similarly to the ordinary bullet-mold on a large scale, but which was mounted on a stand and worked by means of a treadle, through which, aided by the hands of the operator on the handles, the mold was opened and closed, and the gates cut off. This was an ingenious and efficient apparatus, and, with the aid of a boy to pour the lead, could be worked with great rapidity, seemingly limited only by the time required for the cooling of the metal at each cast.

Pressed leaden bullets are undoubtedly superior to cast ones, and those for the ordinary arms in the military service are made in the former way. The lead is generally procured in the form of "bullet wire," coiled on reels. This is cut in lengths of 25 inches, and fed to the machine by a boy. Elongated bullets are formed by a three-part die, which opens and closes with great rapidity, delivering the bullets at the rate of about 3,000 per hour; these have a slight burr or feather at the points where the dies come together, which is afterwards trimmed off by hand.

Molds and rolls are provided with each machine, so that the bars may be cast from the pig, and rolled to give them density; but, as observed above, the lead is generally procured in the form of wire. It is estimated that a man can cast 1,500 bars, or trim and roll 2,000 bars, in a day of ten hours.

Bruff's machine, 1813, has a furnace and a press, in which respectively the lead is cast into

Fig. 971.



Bruff's Bullet-Compressing Machine.

ingots and made into round bullets. The figures are side and end views of the press. The lead is cast into flat plates of the required thickness, and of a width equal to the length of the rolls. It passes from above, downward, between the upper pair of rolls *A*, which are grooved longitudinally; by them it is pressed into round rods, — or, more correctly, long cylindrical pieces, — one half of each of which is formed by the groove in the face of one roll, while the other half is formed by the corresponding groove in the opposite roll, the two working in apposition and moving at an equal rate. Each bar, as it falls from the upper rolls, alights upon the lower roll *B*, which is grooved circumferentially, and carries the round bar against the curved steel plate *C*, whose face is grooved in correspondence to the grooves of the wheel *B*. The bar is nipped between the surfaces, and is cut into sections by the adjacent edges of the roll and plate, and as the pieces roll down in the grooves of the plate and are pressed on the opposite sides in the grooves of the roll, they gradually assume a perfectly spherical form and are discharged.

The elongated shot or bullets now used for rifles are made at Woolwich in the following way: The machine for this purpose consists of four sets of duplicate punches and dies, independently worked in pairs by two eccentrics, driven by gearing from two separate driving-shafts. The lead, coiled round four reels, is fed from them through a shearing-lever into the grippers, where it is clutched; a piece is cut to a suitable length by an upward movement of the shearing-lever; the grippers then open, the piece cut off falls down, and is clutched by another piece of apparatus. At this moment a punch advances, and presses the lead into the die, thus forming a bullet. A small plate comes up immediately in front of the die, and the bullet is pushed through it by a small pin, worked by a lever and cam; by this operation the ragged edge is removed which had been left on the bullet by the die. The machinery, when driven at the rate of thirty revolutions per minute, will make 120 bullets in that time, or 72,000 in a day of ten hours.

Bul'let-mold. An implement opening like a pair of pinchers, having jaws which shut closely together, and a spherical or other shaped cavity made by a cherry-reamer, with an ingate by which the melted lead is poured in.

Bul'let-probe. A sound for exploring tissue to find the *situs* of a bullet. It is usually a soft steel wire with a bulbous extremity. Nelaton used a sound with a file-like extremity, which might receive traces of the bullet in cases where there is doubt of the character of the body with which it is brought in collision. He afterwards used a *sonde*, with a termination of an olive-shaped body of white unvarnished porcelain, which would receive a black mark by contact with the bullet.

Bul'let-screw. One at the end of a ramrod to penetrate a bullet and enable the latter to be withdrawn from the piece. See Ball-screw.

Bul'let-shell. An explosive bullet for small-arms. Jacobs's bullet-shells, used with the rifle of General Jacobs of the East India service, have an inclosed copper tube containing the bursting-charge, which may be fulminate or common powder, and is exploded by a percussion-cap or globule on striking. In experiments made with them at Enfield in 1857, caissons were blown up at distances of 2,000 and 2,400 yards; and brick-walls much damaged at those distances by their explosion. See Bullet.

Bul'ling. (*Blasting.*) Parting a piece of loosened rock from its bed by means of exploding gunpowder poured into the fissures.

Bul'lion. 1. A word whose original meaning indicated a rounded stud or ornament, and came to mean a metallic clasp, boss, hook, button, or buckle.

The meaning has diverged in two directions.

It now means (*a*) a mass of gold or silver in bars or in mass, uncoined; and, by association, a showy metallic ornament or metal-covered fringe; if genuine, of gold or silver, but sometimes a mere colorable imitation in baser metal.

b. A form of heavy twisted fringe, whose cords (L. *bulla*, an object swelling up and becoming round) are prominent; as, in degree, the strands of a cable.

Bullion-fringe for epaulets is made of silk covered with fine gold or silver wire.

2. (*Glass-making.*) The extreme end of the glass bulb at the end of the blowing-tube. The bulb having assumed a conical form is rested on a horizontal bar called the *bullion-bar*, to assist in bringing it to the spherical form.

Bull-nose Ring. A hook whose knobs enter the nostrils and clamp the dividing cartilage or septum of the nose. It is used to lead vicious or obstinate bulls, and occasionally to fasten or hitch them.

A passage in Ezekiel shows that lions and camels were similarly led about, and that prisoners and captives were treated in the same way. Manasseh, the vicious and unfortunate king of Judah, was thus led by the nose, and carried away captive, 677 B. C., by the captain of the host of the king of Assyria. Repenting in exile, he was restored, and died in peace in Jerusalem.

A bas-relief, discovered by Layard at Khorsabad, shows that the practice was considered worthy of illustration by permanent record; and it certainly was far more humane than the Egyptian modes of tying prisoners in the times of the Rameses, and the practices in vogue among the savages of Turkestan at this day, and which we hope are now in course of abatement by Russia.

Bull's-eye. 1. (*Nautical.*) *a*. A small pulley of hard wood, having a groove round the outside and a hole in the middle, answering the purpose of a thimble.

b. A bulb or thick disk of glass let into a ship's side or deck.

c. One of the perforated balls on the *jaw-rope* of a *gaff*.

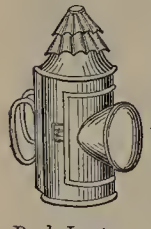
2. The center of a target.

3. The lens of a dark-lantern.

4. (*Glass.*) The central boss which is attached to the bunting-iron or pontil, in the operation of making crown-glass.

5. (*Microscope.*) A plano-convex lens, used as an illuminator to concentrate rays upon an opaque microscopic object.

Fig. 972.



Dark-Lantern.

6. A small lantern with a lens in one side of it, to concentrate the light in any given direction. A *policeman's*, *watchman's*, or *dark* lantern. It has a slide by which the emission of light is prevented, and is unfortunately almost as handy for burglars as policemen. A *dark-lantern*.

Bull's-eye Crin'gle. (*Nautical.*) A wooden ring or thimble used as a cringle in the leech of a sail.

Bull's-nose. (*Carpentry.*) A term sometimes applied to the angle formed by the junction of two plane surfaces.

Bul'wark. 1. A rampart, wall, or parapet around an inclosure, such as a fortification or battery.

The *boulevards* of Paris and other cities are on the site of the ramparts of the former fortifications.

2. (*Nautical.*) The sides of a ship above the upper deck.

Bum'boat. (*Nautical.*) A boat used to carry provisions to vessels. So named from its clumsy form.

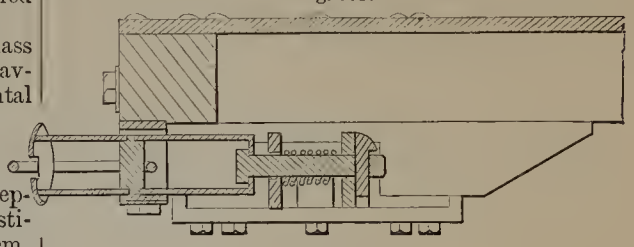
Bum'kin; Boom'kin. (*Nautical.*) *a*. A boom on each side of the bow, to haul the fore-tack to.

b. On the quarter for the standing part of the main-brace.

c. Over the stern, to extend the mizzen.

Bump'er. A projecting head at the end of a railway-car, to receive or deliver the contact when cars

Fig. 973.

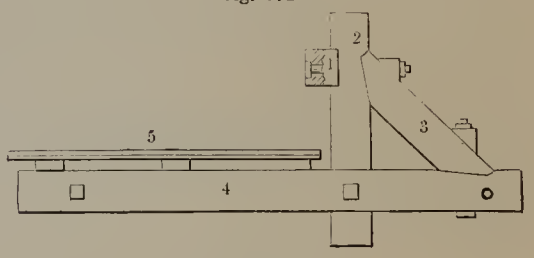


Car-Bumper.

come together, and, by transferring the force to a spring, moderate the jar incident to the collision. In the illustration the spring is of a spiral form. See also BUFFER.

Bump'ing-post. (*Railway Engineering.*) A timber or set of timbers at the termination of a railroad track, to limit the motion of the train in that direction. In the example, the three members, —

Fig. 974.



Bumping-Post.

sills 4, posts 2, and braces 1 3, — are bolted together, and a part of the strain transferred from the posts and thrown upon the sill beneath the track.

Bunch. 1. (*Mining.*) The expanded portion of a *pipe-vein*; that is, one which, instead of preserving a uniform size, has contractions and expansions. A body of ore not continuous like a *course*. Also called a *squat*.

2. (*Flax-manufacture.*) Three bundles, or 180,000 yards, of linen yarn.

Each *bundle* has 60,000 yards, and is made up of 20 hanks, each having 10 *leas*, and each *lea* being 300 yards in length. See BUNDLE.

Bun'der-boat. The surf-boat of the Malabar coast of India.

Bun'dle. (*Flax-manufacture.*) Twenty hanks, or 60,000 yards, of linen yarn make a *bundle*.

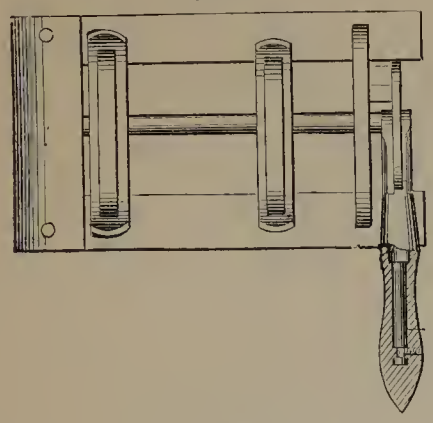
Table.

120 *yarns* of 2½ yards	= 300 yards = 1 *lea*.
10 *leas*	3,000 yards = 1 *hank*.
20 *hanks*	60,000 yards = 1 *bundle*.
3 *bundles*	180,000 yards = 1 *bunch*.

Bun'dle-pil'lar. (*Architecture.*) A column or pier with others of small dimensions attached to it.

Bun'dling-ma-chine'. One for grasping a number of articles into a bundle ready for tying. Machines of this character are used for fire-wood, asparagus, and many other things sold in tied bundles. The handle is adjusted in position to expand the bands or straps for receiving the article to

Fig. 975.



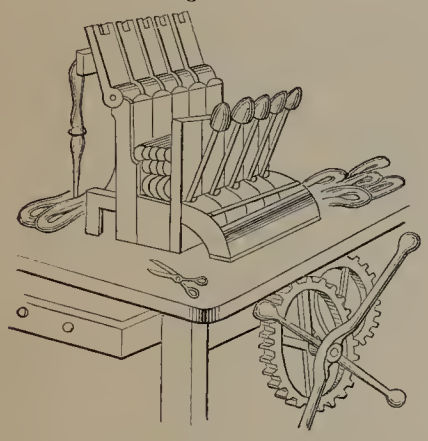
Bundling-Machine.

be bound, when it is drawn down, and by a slight turn of the hand-piece the machine will be locked and the bundle held securely until tied up.

Bun'dling-press. A press in which hanks of yarn are pressed into cubical packages for transportation, storage, or sale.

The press has an iron frame beneath the wooden table, on the respective ends of which the yarn and the tying twine are placed. The hanks of yarn are

Fig. 976.



Bundling-Press.

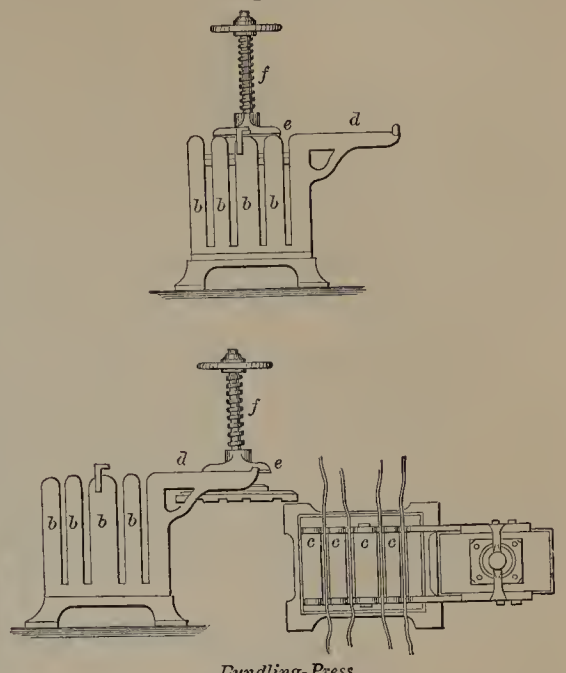
placed between the standards of the press-box, the sides of which are slotted, to allow the strings to be laid in position before the yarn is filled in. The top is then shut down and secured by the key-rods, which enter the notches in the top bars.

The iron cross is then turned, operating a pinion beneath the table; the pinion engages with and turns a large cog-wheel, to one of whose arms a pitman is connected. The pitman raises the follower, which forms the bottom of the press-box, and squeezes the bundle of hanks against the top pieces which form the cover. The strings are then brought around and tied, the slits in the sides and top of the box permitting them to come against the cotton.

After tying, the pressure is slackened, the key-rods withdrawn, the cover thrown back, and the tied bundle withdrawn.

The invention shown in Fig. 977 is primarily designed for bundling yarn, but is adapted for compressing other like materials. It consists of a frame having uprights *b b* at each side, carrying transverse bars *c c* at top. For use, the yarn to be bundled is placed on the bars *c c*, the platen *e* having been previously run out on the extension *d*;

Fig. 977.



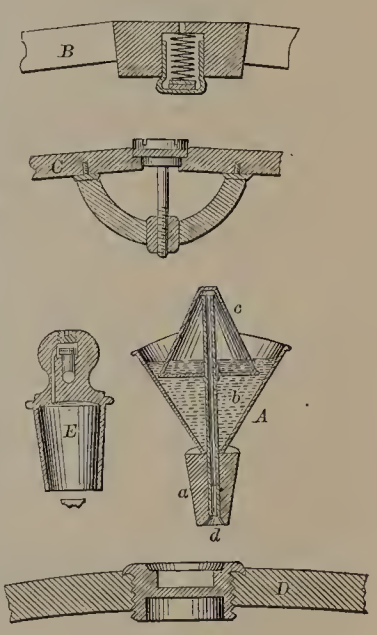
Bundling-Press.

cords are passed around the bundle, and the platen is run in on its guides and forced down by means of the screw *f*, compressing the wool into a small space; the cords are then tied, the platen run out again, and the bundle removed.

Bung. 1. (*Coopering.*) A stopper for the large opening in the bulge of a cask called the *bung*-hole.

The common bung is merely a thick circular piece of wood or cork, over which a square piece of tin is usually nailed. Improved devices relate to means for admitting air to allow the contained liquid to be drawn, or for permitting gases generated inside to escape before attaining a dangerous degree of pressure.

Fig. 978.



Bungs.

Fig. 978 (*A*) is designed to allow the carbonic acid generated during the process of fermentation to depart without allowing access of external air, whose oxygen aggravates the process.

The carbonic acid passes up tube *d* in the bung *a*, and escapes into the air around the lower edges of the cone *c*, which is submerged in the reservoir *b*, the latter being filled with water, or preferably with the must, wine, or beer with which the cask is filled.

It is a substitute for a bent tube, inserted into the bung, and its other end inverted into a tumbler of liquid which stands on the top of the cask.

B is a bung with a spring plug.

C has an inner bridge into which the stem of the bung screws.

D is a screw-bung.

E is a bung with a vent and a screw vent-plug.

2. (*Pottery.*) A pile of *seggars* forming a cylindrical column in a kiln.

Bung-bor'er. (*Coopering.*) A conical auger for reaming out a bung-hole.

Bung-cut'ter. A machine for cutting bungs. There are four forms: —

1. The annular borer. (See AUGER.) This has a pointed cutter on a stem, like a center-bit without the routing-cutter.

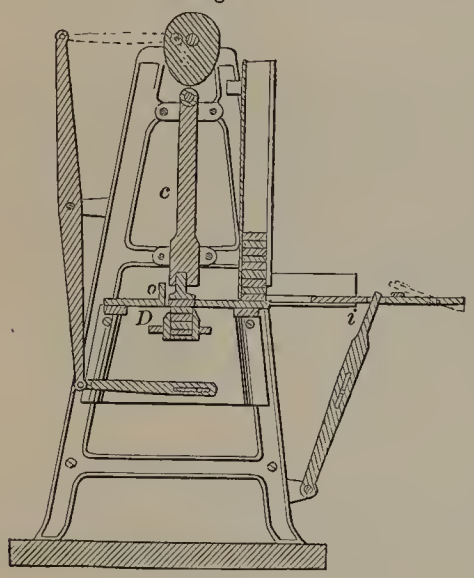
2. A lathe which turns the circular bung.

3. A cylindrical saw which advances against the blank (or conversely) and cuts out a circular disk.

4. A descending tubular knife which cuts the disk out of the stuff, or cuts a square blank into a circular shape.

Of the latter class is Fig. 979, in which the square blocks are placed in a vertical pile in the hopper, and fed automatically one by one to the plunger, by which they are forced through the circular cavity of

Fig. 979.



Bung-Cutter.

the cutter and formed into cylindrical blanks. *i* is the feeding slide-bar which pushes the lowest blank of the pile beneath the plunger *c*, which forces it down upon the circular cutter *D*.

Bun'go. (*Boat.*) A kind of canoe used in the Southern States and in South America.

Bung-start'er. (*Coopering.*) A *flogger*. A bat to start the bung of a cask by beating on the bulge alongside of the bung.

Bung-vent. A passage for admitting air through the bung of a cask, to allow a free flow of liquid from the tap. In the example, the cavity in the bung communicates with the atmosphere and with the interior of the barrel by separate passages. The valve in the cavity rises freely to admit air, but resists the passage of gases from the barrel. See also BUNG.

Fig. 980.

Bung-Vent.

Bunk'er. (*Nautical.*) A coal-space below decks on steamers.

Bun'sen-bat'ter-y. Invented by Bunsen, Professor of Chemistry at Breslau. Also called the *Electropoion Battery* and the *Carbon Battery*. A modification of the Grove battery, carbon or gas-coke replacing the platinum, and a solution of bichromate of potash replacing the nitric acid of the Grove battery.

In this form of battery, the carbon or coke is sometimes formed into a cup, replacing both the platinum and the porous cup.

There are several modifications of the Bunsen battery, mainly mechanical, looking to a more compact arrangement of the elements, economizing space, etc.

There are also several formulas for the bichromate solution: —

Bunsen: 5 pounds bichromate of potash dissolved in 2 gallons boiling water.

Prevost (September 27, 1870): water, 800: bichromate potash, 50; sulphuric acid, 50; chromic acid, 2.

V. Barjou: bichromate of potash, quicklime, sulphuric acid.

Bastet (September 26, 1871): bichromate of potash, water, nitrates of either soda or potassa, and sulphuric acid.

Bunt. (*Nautical.*) The middle perpendicular portion of a sail.

Bunt'ing. (*Fabric.*) A thin woolen stuff of which flags are made.

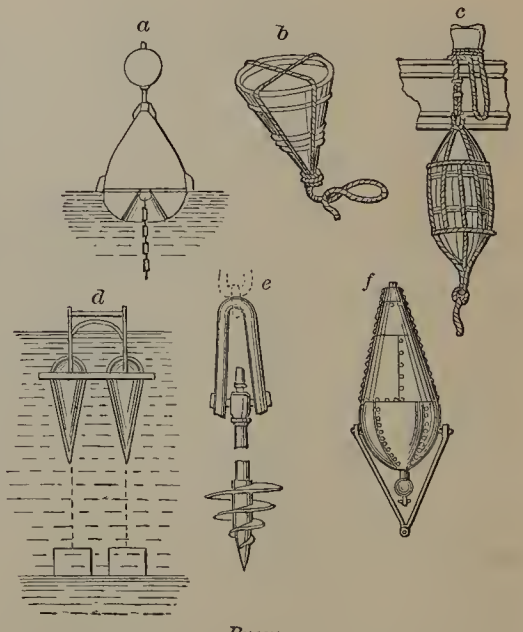
Bunt'ing-i'ron. (*Glass.*) The glass-blower's pipe.

Bunt'line. (*Nautical.*) One of the ropes attached to the foot-rope of a sail, which passes in front of the canvas, and is one of the means of taking it in, turning it up forward so as to spill the wind and avoid bellying.

Bunt'line-cloth. (*Nautical.*) The lining sewed up a sail under the buntline, to prevent the rope from chafing the sail.

Buoy. A floating body anchored or fastened in the vicinity, and employed to point out the position

Fig. 981.



Buoys.

of anything under water, as a ship's anchor, reef, shoal, or danger of any kind.

Buoys, in general, are divided into three kinds: the *nun-buoy* (*c*), which is in the form of a parabolic spindle, generally truncated at one end, and when

intended as a mark by which to point out a shoal, arranged to carry a mast or frame of cage-work, and loaded so as to float in a vertical position. Smaller buoys of this kind are used as anchor-buoys.

The *can-buoy* (*b*) is conical, frusto-conical, or conoidal in shape, and floats upon its side when moored.

The *cask-buoy* is a short frustum of a spindle, truncated at each end; it is sometimes cylindrical or nearly so. It is chiefly used for carrying the warps of vessels laying at moorings. A good tight common cask may be used for the same purpose, and is far less expensive.

Life or *safety buoys* are intended to save the life of a person falling overboard. They are suspended below a ship's taffrail, and are so arranged that they can be let go at a moment's notice; the same pull which casts the buoy loose lighting a port-fire, to indicate the position of the buoy to the person overboard as well as to the crew of the boat sent to pick him up, thus serving as a point of resort for both. Such is the life-buoy of Lieutenant Cook. A fuse, composed of a proper mixture of phosphide of calcium, is attached to the buoy. In case of a man overboard, the life-preserver is thrown into the water; the moment the fuse becomes wet, it begins to give off a gas which takes fire in the air; and the wetter it becomes the more gas and the brighter the light produced. The light can be made to last an hour. See LIFE-BUOY.

Spar-buoys are also frequently employed to point out channels in rivers and less exposed situations; these are nothing more than masts or spars of proper length, painted of any desired color, and anchored.

Buoys are made either of wood or sheet-iron; gutta-percha stretched on wooden or metallic frames has also been proposed.

When employed to point out shoals or dangers, they are painted of some distinctly visible color, and where more than one is anchored in the same vicinity, their colors are varied so that they may be readily distinguished from each other; for example, the buoys on one side of a channel may be black and those on the other red, so that the navigator can tell at once, by the color, on which side they are to be passed. Herbert's buoy (*a*) is intended to be anchored by having the mooring-chain attached near its center of gravity, so as to reduce the tendency to pitch and roll in rough water and impart greater stability to the buoy; the shape of the buoy and the conical hollow in its base also conduce to these objects.

An improved buoy (*f*), designed to have similar advantages, was patented by W. M. Ellis, Oct. 7, 1856. It is moored by attaching the cables in the line of the calculated center of tidal pressure; and the forked or V-link or shackle is connected to the buoy by means of a trunnion-bolt passing through a metallic tube or pipe set and secured within the buoy. The figure *f* will show the method of effecting these objects.

Submerged buoys have been suggested, anchored by a weight heavier than the floating power of the buoy. As the weight ceases to exert a sinking force when it reaches the bottom, the capacity of the buoy to sustain a load is the same as if it floated at the surface, and an upright or spindle on its upper part presents but a small surface to the action of waves. Two or more such buoys sunk to the dead-water point may be so arranged as to support a superstructure above the level of the sea, as in *d*.

Buoys in certain situations may be moored by screw-piles (*e*), which are readily driven by rotation into the sand or mud, and energetically oppose retraction.

Other designations are: —

Anchor buoy, one attached by a rope to an anchor to show the position of the latter.

Cable buoy, an empty cask to keep a hempen cable above the bottom in rocky anchorage.

Leading buoy, in the form of a millstone.

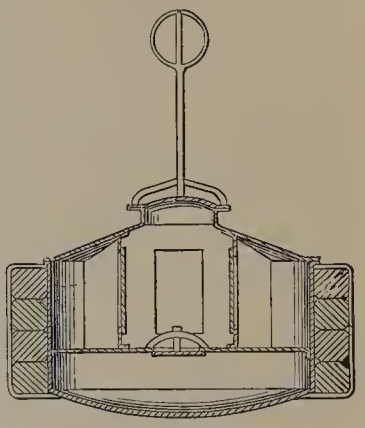
Sounding buoy, used in sounding an anchorage-ground.

The *slings* of a buoy are the part of the buoy-rope bent to or around the buoy.

Buoy-rope. (*Nautical.*) The rope which fastens a buoy to an anchor.

Buoy-safe. A metallic body divided into compartments, by which it is braced, and having water-tight doors opening to the inside. The buoy has an encircling armor of cork.

Fig. 982.



Buoy-Safe.

Bur; Burr. 1. (*Machinery.*) A small circular saw or toothed drum used on a mandrel placed between the centers of a lathe.

2. (*Metal-working.*) A roughness left on metal by a cutting-tool, such as a graver or turning-chisel. The bur of a graver is removed by a scraper; that of a lathe-tool by a burnisher or in the polishing process. A bur is purposely made on a currier's knife and a comb-maker's file, and in each case constitutes the cutting edge.

3. (*Knitting-machine.*) A wheel with thin plates or projections inclined to the axis of the bur, and used to depress the thread between the needles and below the *beards;* it is then called a *sinker*. It becomes a *knocker-off* when it raises the loops over the top of the needle. See SINKER.

4. A fluted reaming-tool.

Fig. 983.

Dentist's Burs.

5. (*Dentistry.*) A dentist's instrument of the nature of a drill, but having a serrated or file-cut head, larger than the shank. The instruments are made of many sizes, and the heads are spherical, bulbous, cylindrical, frustal, disk-shaped, or conical.

In the example are shown the *round*, *wheel*, *inverted cone*, *cone*, *cylinder*, *cylindroid*, *conoid* burs.

6. A triangular chisel.

7. A planchet driven out of a sheet of metal by a punch.

8. A washer placed on the small end of a rivet before the end is swaged down.

9. The *jet*, *sprue*, or neck on a cast bullet.

Bur-chis'el. A triangular chisel, used to clear the corners of mortises.

Bur-cut'ter. (*Metal-working.*) A nippers for

cutting away the flange from a leaden bullet or ball. A *bur-nipper*.

Bur'den. 1. (*Nautical.*) The tonnage or carrying capacity (by weight) of a vessel.

2. (*Metallurgy.*) The charge of a furnace.

3. (*Mining.*) The tops or heads of stream work, which lie over the *stream* of tin.

Bur-dett'. (*Fabric.*) A cotton stuff.

Bur-drill. A drill with an enlarged head used by operative dentists.

Fig. 984.

Bur-Drills.

The set consists of five varieties: The pulp-canal reamer, small and larger; the round bur-drill; the excavator; the undercutting bur-drill. See also BUR.

Bu-rette'. A small, graduated glass tube used in pharmacy or in the laboratory for measuring or transferring small quantities of liquid. It sometimes has a stop-cock, and the discharge through its small orifice is sometimes checked by the finger placed on the opening above, as in the *velinche* or *pipette*.

As invented by Gay Lussac, for dividing a fluid into minute portions, it consists of a large tube, graduated to $\frac{1}{100}$ and $\frac{1}{1000}$, and a smaller parallel connected tube.

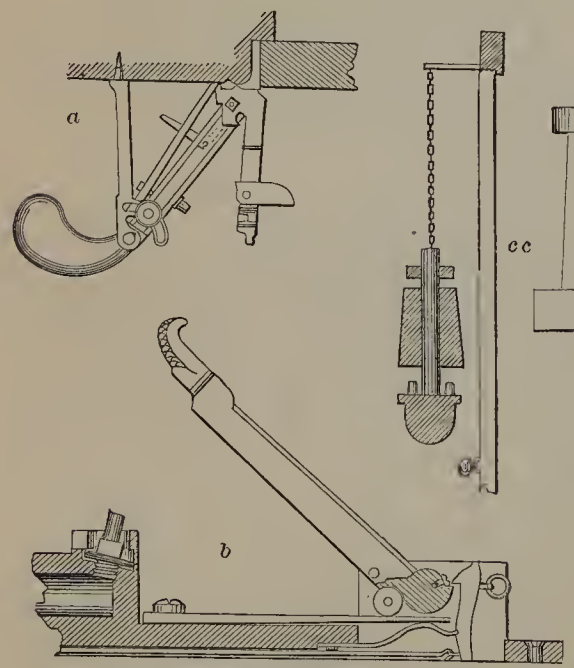
Bur-gage. (*Metal-working.*) A plate perforated with holes of graduated sizes, whose numbers determine the trade sizes of drills and burs.

Bur-gee'. (*Nautical.*) A flag ending in two points. See FLAG.

Bur'geoise. (*Printing.*) A size of type. See BOURGEOISE.

Burg'lar-a-larm'. A device to be attached to a door or a window, to make an alarm when it is opened from without. Some alarms are portable, to be used by travelers in securing their doors against intrusion. As their name indicates, they are intended to make a noise when started, and they consist of bells, pistols, or torpedoes, sometimes associated with devices for lighting a lamp, and in one case (POWELL, July 23, 1861) having an arrangement for upsetting the bed, and thereby calling the attention of the sleeper to the disturbance. The contrivance instanced by the Marquis of Worcester, with alarm, fire, tinder, and pistol, is described in his "Century of Inventions," and is cited *ante*, page 56.

Fig. 985.



Burglar-Alarms.

One device has a hinged plate on the threshold of the door, and partially concealed by the carpet. The foot of a person entering the room depresses the plate, and by means of a lever and rod actuates a bell, whose ringing gives notice of the presence of the intruder.

Another: an ordinary clock-alarm is placed within a case attached to the door, and is sprung by the opening of the door.

The illustration shows three forms: a pistol *a* fastened to the door-jamb by its pivoted post, whose tang screws into the jamb. Its muzzle is presented towards the crack of the door, and its trigger is tripped when the door opens, with consequences to the chambermaid or too impulsive friends.

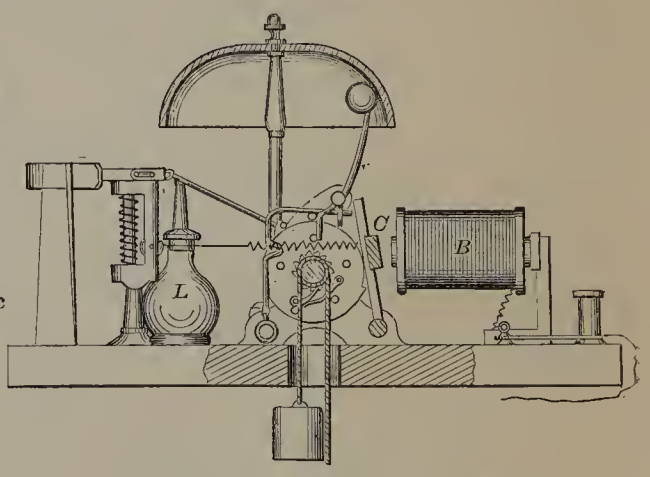
b is placed anywhere in the room, and is tripped by a cord leading to a door or window whose surreptitious opening is to be announced.

c is a torpedo suspended by a pin from the door, and dropped when the latter opens.

Fig. 986 shows one of the numerous forms of the application of the electric circuit and apparatus to guard the windows and doors of a house.

Copper wires running through the house are connected with a battery, and have circuit connections attached to the doors and windows, so that when a door or window is opened the armature is released

Fig. 986



Electro-Magnetic Burglar-Alarm.

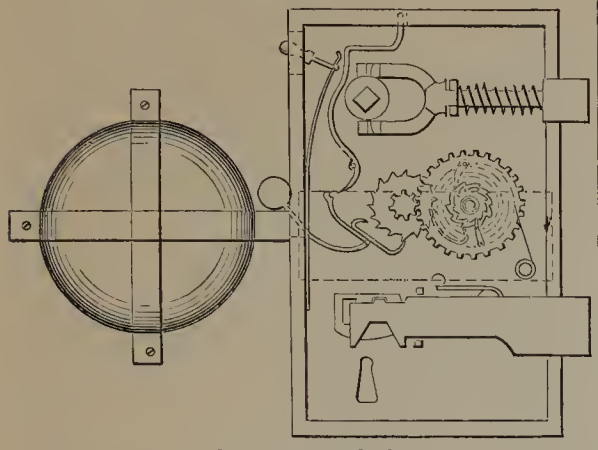
from the magnets, and causes a bell to strike, and lights a fluid lamp or candle.

The circuit being completed by the motion of the door or window, the magnet *B* attracts the armature *C*, and sets free the detent, so that the weight runs the alarm-hammer, while the match-puller is reciprocated and lights the lamp *L*.

Burg'lar-a-larm' Lock. A lock with an alarm apparatus attached so that, when properly set, the same will be put in operation and an alarm sounded, in case the bolt of the lock is improperly moved.

When the latch is drawn in, the escapement is set in motion, being driven by the cog gearing and spring, each pulsation of the escapement-lever being a blow of the hammer upon the bell.

Fig. 987.



Burglar-Alarm Lock.

Bur'i-al-case. A mummy-shaped form of coffin, made of various materials, wood, metal, earthenware, concrete, asphaltum compounds, papier-maché. Its furnishing and arrangement involve improvements in the lids, glass over the face, means of fastening, hermetical sealing, and the complete isolation of the body from air by enveloping the corpse in a resinous or other air-excluding compound.

Bu'rin. 1. (*Engraving.*) The cutting-tool of an engraver on metal. A graver.

2. (*Masonry.*) A triangular square-shaped steel tool whetted off obliquely at the end, so as to exhibit a diamond. It is shaped like a graver, and is used by the marble-worker.

Bur'lap. (*Fabric.*) A coarse, heavy goods for wrapping, made of jute, flax, manilla, or hemp.

Burl'ing. (*Woolen-manufacture.*) A process in which woolen cloth is examined for rents, flaws, knots, defective yarns, etc., a deficiency being made good with a needle, and offensive matters removed. This is done after *scouring* and before *fulling*.

Burl has the same old English definition as *Bur*, and the name of the process is probably derived from the plan of picking out the *burs* from the cloth.

Burl'ing-i'ron. (*Woolen-manufacture.*) A sort of pinchers or nippers, used in *burling* cloth.

Burl'ing-ma-chine'. One for removing knots and foreign matters projecting from the surface of woolen cloth before fulling.

Burn'er. That part of a lighting apparatus at which combustion takes place. See GAS-BURNER; LAMP-BURNER.

Also applied to the corresponding portions of *gas-heaters* and *gas-stoves* (which see). See also VAPOR-BURNER; PETROLEUM STOVE.

Bur'nett-iz'ing. A process for preventing decay of wood and fibrous materials or fabrics, patented in England by Burnett, 1837.

The wood or fiber is immersed in a solution of chloride of zinc, 1 pound; water, 4 gallons for wood, 5 gallons for fabrics, 2 gallons for felt, contained in a wooden tank.

Timber is saturated two days for each inch of thickness, and then set on end to drain for from two to fourteen weeks.

Cotton, yarns, cordage, and woolens are immersed for forty-eight hours.

Burn'ing. 1. (*Metal-working.*) Joining metals by melting their adjacent edges, or heating the adjacent edges and running into the intermediate space some molten metal of the same kind.

It differs from soldering in this: —

In burning, a heat is required sufficient to melt the original metal, and a flux is seldom used.

In soldering, a lower heat is used and a more fusible metal employed, assisted by a flux.

The superior quality of the former process arises from the fact that the joint will withstand the same heat as the body of the article.

It is apt to be stronger, as the article soldered has usually more tenacity than the solder; tin-plate or copper than the alloy of tin and lead, for instance.

The article *burned together* being homogeneous, the parts expand and contract evenly by changes in temperature; the solders have a greater range of expansion by given changes of temperature than the metals they connect.

The solders oxidize more or less freely than the metals they connect, and establish galvanic circuits which destroy the integrity of the joint; especially in the presence of heat, moisture, or acids.

As an instance, the leaden vessels and chambers for sulphuric acid cannot profitably be united with tin solder, as the acid acts so freely on the tin. The joint was therefore made by doubling the edges in a hollow lap and pouring red-hot lead on to the joint. This is now performed by *burning together*, the heat being applied by an airo-hydrogen blow-pipe. See BLOW-PIPE.

Pewter is *burned together* by a nearly red-hot soldering-bit, which melts a strip of pewter laid in the angle. Superfluous metal is filed off when cold.

Brass is burned together, as in the case of brass mural circles for observatories, that are from 4 to 6 feet in diameter, and are cast in six or more segments.

The ends of the segments are filed clean; two pieces are fixed vertically in a sand-mold, in their relative positions; a shallow space is left around the joint, and the entire charge of a crucible, say thirty or forty pounds of the melted brass, a little hotter than usual, is then poured on the joint to heat it to the melting-point. The metal overflows the shallow chamber or hole, and runs into a pit prepared for it in the sand, but the last quantity of metal that remains solidifies with the ends of the segments and forms a joint almost or quite as perfect as the general substance of the metal. The process is repeated for every joint of the circle.

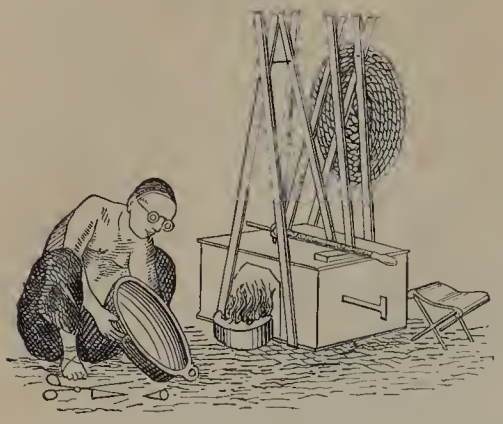
Cast-iron is also united by burning. It was first practiced by the native smiths of India and China, who occasioned much surprise to their Occidental neighbors by the way in which they mended cast-iron kettles and pots, which were supposed to be irretrievably ruined.

The first notice of it by Europeans appears to have been by Van Braam, in 1794–95, who was attached to the Dutch Embassy at Pekin, and who afterwards settled in the United States.

The figure represents the itinerant artist with his portable forge, at work in the street. The front half of the wooden chest is his *Fung-Seang*, or bellows. Its principle is that of the double-acting force-pump, and it is constructed wholly of wood, except the valves and packing of the piston, which are paper, and singularly durable. The long coarse file, with a prolonged smooth extremity to slide through a ring, fixed on the chest, is a common accessory to a tinker's budget. By the arrangement, he possesses a tolerably good substitute for a bench and vise, and can increase or diminish the pressure of the file on the object operated on, at pleasure.

The European plan for *burning together* cast-iron surfaces consists in using an excess of metal which is poured continuously through the fissure until the edges of the metal are in a semi-fluid condition,

Fig. 988.



Burning.

much as in the case of the brass mural circles previously mentioned.

As nearly analogous to the just-described processes, may be mentioned in this place the modes of uniting metal to metal by simple heat and contact.

A thin plate of silver and a stouter bar of copper, their surfaces being scraped perfectly clean, are tied together by a binding-wire and united by partial fusion without the aid of solder. The two metals are raised to a heat just short of the melting-point of silver, and when afterwards rolled the two metals maintain a perfect contact and the same proportional thickness however attenuated they may become.

The compensation balance of the chronometer and superior watches is another example of the union of metals by heat and contact.

The balance is a small fly-wheel made of one piece of steel, covered with a hoop of brass. Its principles and applications are described under BALANCE (which see). The two metals are thus united: the disk of steel, when turned and pierced with a central hole, is fixed by a little screw-bolt and nut to the bottom of a small crucible with a central elevation smaller than the disk. The brass is melted and poured into the crucible around the disk. When cooled, the crucible is broken, the superfluous brass is turned off in the lathe, the arms are made by the file as usual, and lastly, the hoop is divided in two places, at opposite ends of its diametrical arm.

A little black-lead is sometimes introduced between the steel disk and the crucible.

The airo-hydrogen blow-pipe, a modification of the oxyhydrogen blow-pipe invented by Dr. Hare, of Philadelphia, is used in melting the adjacent edges of metals so as to unite them by fusion, or in fusing strips of the same metal over a seam or joint where the edges of sheet-metal abut upon each other. See BLOW-PIPE.

2. (*Ceramics.*) The final heating of clay ware, which changes it from the *dried* or *biscuited* condition to the perfect ware. The glaze or enamel is applied to the *baked* ware, and is vitrified in the *burning*.

Burn'ing-glass. (*Optics.*) A convex lens of large size and short focus, used for causing an intense heat by concentrating the sun's rays on a very small area.

Pliny states that the ancients had globes of glass and crystal which produced fire, and Lactaneus adds that a glass sphere full of water did the same.

Any convex lens may be employed as a burning-glass, its calorific effect, as in the case of a mirror, being proportional to the number of rays concentrated in a given area, or to the relative circular areas of the lens and the spot on which the refracted rays fall.

About 1774, M. de Trudano constructed a hollow glass lens, of 11 feet focus, filled with oil of turpentine, of which it held 140 Paris pints (nearly equal to the same number of English quarts). By this lens a bar of steel 4 inches long and $\frac{1}{3}$ of an inch square was melted in five minutes. Three and six livre silver pieces were fused in a few seconds, and grains of platinum were melted sufficiently to cohere, but not to form a spherical drop.

The "Parker" lens or burning-glass was made in London at a cost of $3,500. It was of flint glass, 36 inches in diameter, double convex, its sides portions of a sphere of 18 feet radius. Its focus was 6 feet 8 inches; diameter of focus at that distance, 1 inch; weight, 212 pounds. A second lens, of 16 inches diameter and weight 21 pounds, was used to concentrate the rays, the focal distance being then 63 inches, the diameter of focus $\frac{1}{2}$ inch. This lens was carried to China by an officer in the suite of Lord Macartney, and left at Pekin.

The effects of the burning arrangement were as follows: —

Substances.	Weight. Grains.	Time. Seconds.	Substances.	Weight. Grains.	Time. Seconds.
Gold (pure)	20	4	Carnelian	10	75
Silver (pure)	20	3	Jasper	10	25
Copper (pure)	33	20	Onyx	10	20
Platinum			Garnet	10	17
(pure)	10	3	Spar	10	60
Nickel	16	3	Rotten-stone	10	80
Bar-iron	10	12	Slate	10	2
Cast-iron	10	3	Asbestos	10	10
Steel	10	12	Limestone	10	35
Topaz	3	45	Pumice-stone	10	24
Emerald	2	25	Lava	10	24
Flint	19	30	Volcanic clay	10	60

See BURNING-MIRROR.

Burn'ing-house. (*Metallurgy.*) A miner's term for a kiln or roasting-furnace in which volatile mineral matters are expelled, as the sulphur from tin pyrites. A kiln.

Burn'ing-mir'ror. A concave mirror, or a combination of plane mirrors, so arranged as to concentrate the sun's heating rays on a common object.

The most celebrated of these are the mirrors of Archimedes, who thereby burned the Roman fleet of Marcellus at Syracuse. Each concave mirror was separately hinged, and they were brought to bear in combination upon the object in the common focus.

In Peru, previous to the Spanish Conquest, the rays of the sun were collected in a concave mirror and fire kindled thereby.

Besides the familiar instance of the burning of the fleet of Marcellus by Archimedes, another instance is cited by the historian Zonaras, who records that Proclus consumed by a similar apparatus the ships of the Scythian leader Vitalian, when he besieged Constantinople in the beginning of the sixth century. It must, however, be mentioned that Malaba, another old chronicler, says that Proclus operated on this occasion by burning sulphur showered upon the ships by machines.

Stettala, a canon of Milan, made a parabolic reflector with a focus of 45 feet, at which distance it ignited wood. It is understood to be the first of that form, though Digges in the sixteenth century, Newton and Napier in the seventeenth century, experimented with parabolic mirrors.

Villette, an optician of Lyons, constructed three mirrors about 1670. One of them, purchased by the King of France, was 30 inches in diameter and 36 inches focus. The diameter of the focus was

about 1 inch. It immediately set fire to green wood; it fused silver and copper in a few seconds, and in one minute vitrified brick and flint earth.

The Baron von Tchionhausen's mirror, 1687, was a concave metallic plate 5 feet 3 inches in diameter, and having a focal length of 3½ feet. Its effects were similar to those of the mirror just cited, and it is recorded that slate was transformed into a kind of black glass, which, when laid hold of by a pair of pinchers, could be drawn out into filaments.

Buffon made a machine with 140 plane mirrors 4 × 3 inches, placed in a frame and separately adjustable by temper-screws. With 24 of the mirrors adjusted to a common focus at a distance of 66 French feet, he fired pitch and tow. With a polyhedron frame set with 168 pieces of plain looking-glass, 6 inches square, he fired beechwood at 150 feet, and melted a silver plate at 60 feet. He then constructed one on similar principles, with 360 mirrors 8 × 6 inches in a frame 8 × 7 feet. With this most metals were melted at 25 to 40 feet distance, and wood was burned at 210 feet distance.

Burn'ing-on. A process of mending castings by uniting two fractured portions, or by attaching a new piece to a casting.

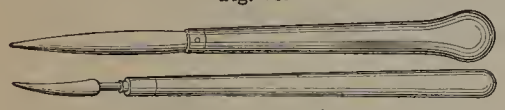
The casting is so fitted into a mold, in connection with a pattern, that the latter portion shall represent the piece required. The mold being opened, the pattern is removed and the mold reclosed, leaving the casting in position. Metal is then flowed through the mold until the face of the casting becomes softened, when the flow is stopped, and the mold allowed to fill in the usual manner.

When two castings are to be united, the molten metal is poured through a space between them until the respective surfaces become softened so as to unite fairly with the metal. The flow is stopped and the chink allowed to fill. It is then cooled in the ordinary manner. See BURNING.

Bur'nish-er. A tool for smoothing or pressing down surfaces to close the pores or obliterate lines or marks.

The engraver's burnisher is made of steel, elliptical in cross-section, and coming to a dull point like

Fig. 989.



Engravers' Burnishers.

a probe. The larger one in the figure is the ordinary form, and the smaller one is used by stipple-engravers.

Burnishers are often made of dogs' teeth (the canine tooth), which is of a convenient shape and size for some purposes, and, like other teeth, has a very hard enamel.

They are also sometimes made of agate, which is an extremely hard mineral, and is useful in burnishing paper for collars. Paper is much more wearing than steel softened for the engraver or die-sinker, owing to the presence of silex in the fiber.

Burnishers of bloodstone are used for putting gold-leaf on china-ware.

Agate burnishers are used by bookbinders.

The gilder's burnisher is of agate or porphyry.

A round *broach* is used for burnishing pivot-holes.

For cutlers' use the burnisher is inlaid into a piece of wood with handles like a spoke-shave.

The *clog-burnisher* used by cutlers is inserted into a handle which has a ring and staple at one end, so that the left hand of the operator is free for handling the work.

For still larger work, the burnisher is at the bottom end of a pole suspended from the ceiling.

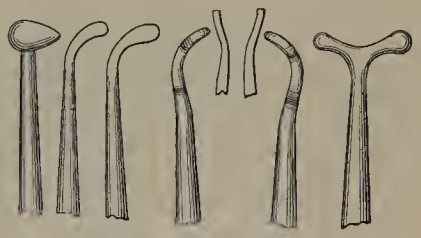
A flat-bladed burnisher is used in restoring the edges to the teeth of the comb-maker's files. These teeth are made by a file, not a chisel, and have a forward inclination of 15°.

A round burnisher is also used to restore the edge to the steel scraper used by cabinet-makers in finishing surfaces, especially of veneers.

Also by the currier in preserving the wire-edge of his knife. Called a *steel*, and resembling an *awl*.

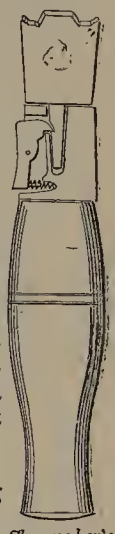
The dentist's burnisher has a bulbous, spherical, or probe-shaped termination for smoothing the surface of metallic filling of teeth.

Fig. 990.



Dentists' Burnishers.

Fig. 991.



Shoemaker's Burnisher.

The shoemaker's burnisher is for finishing the edges of boot-soles. In the example, the tool has a movable head and a metallic socket, so that the stock need not be injured when the head is heated for use. See BURNISHING-MACHINE.

Bur'nish-gild'ing. A mode of gilding consisting of the following processes: —

The stuff for picture-frames, looking-glasses, etc., or other object to be gilt, is —

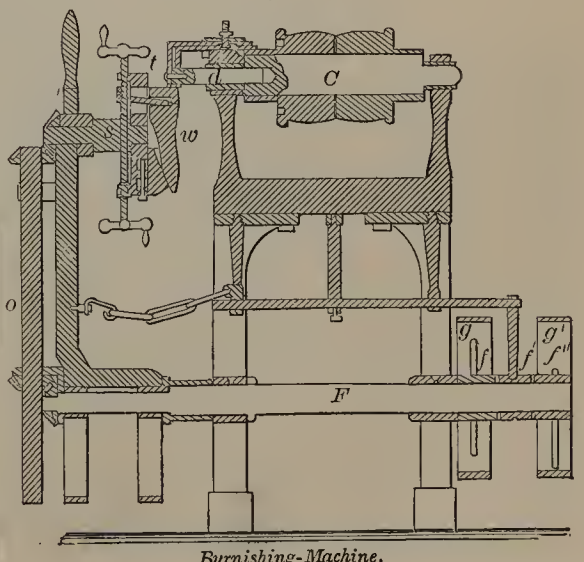
Primed with white stuff in several coats. This consists of hot size and whiting.

The surface is smoothed with pumice-stone and glass-paper.

It then receives a number of coats of a peculiar size, formed of pipe-clay, red-chalk, black-lead, suet, and bullock's blood, thinned with a solution of gelatine.

On this the gold-leaf is laid and burnished. See GILDING.

Fig. 992.



Burnishing-Machine.

Bur'nish-ing-ma-chine'. One for giving a polish by compression. Such are the machines for burnishing paper-collars and boot-soles. One of the latter is shown in Fig. 992.

The last *w* is secured eccentrically to the cross-head *t*, which receives motion from the shafts *s o F* and band-wheels *g g'*. By means of a clutch *f f' f''* the motion may be reversed so that the boot-sole may be burnished to one shank and then turned back again. The burnishing-tool also revolves with its stock *d* and mandrel *C*, but is adjusted relatively to the boot-sole by sliding-gages which do not partake of the motion.

Burr. 1. The waste or refuse of raw silk.

2. A vitrified brick.

In a mechanical sense, see BUR.

Bur'ras-pipe. A tube to contain lunar caustic or other corrosive.

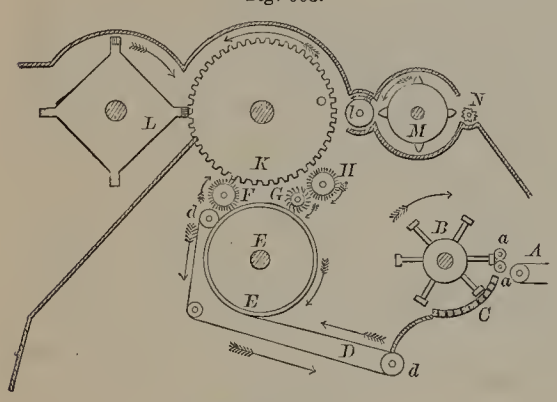
Bur'rel-shot. (*Projectiles.*) A medley of shot, stones, chunks of iron, etc., to be projected from a cannon at short range. Emergency shot. *Langrel.*

Bur'ring. (*Woolen-manufacture.*) A process in the manufacture of wool by which burs and foreign matters are removed from the wool, which has been opened by the preceding *willowing*-process.

Bur'ring-ma-chine'. A machine for *picking* and *burring* wool. It follows the *willowing* machine and precedes *carding*.

A *picking and burring machine* is exhibited in a section which displays the working parts. *A* is the feed-cloth by which the wool is carried into the machine; *a a* are two fluted iron rollers which draw in the wool, and it is then exposed to the action of

Fig. 993.



Burring-Machine.

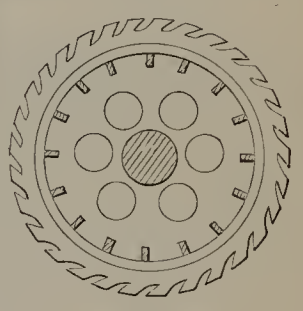
a heavy iron beater *B*, which, revolving in the direction of the arrow, beats and separates the wool and throws it down on the cloth *D*, while dust and dirt pass through the grating *C*. The cloth *D* has a chain fastened to each side, the links of which work into studs on the rollers *d d*, thus insuring regularity of motion; the loose wool is carried forward by this cloth under the wire cage *E*, which, pressing upon it, forms it into a loose lap or fleece. This is taken off the cloth by the brush *F*, and transferred by it to the comb-cylinder *K*, which has a number of fine iron combs, set longitudinally round its circumference. By the revolution of the cylinder the wool is carried on to the card-roller *G*, which takes it off the comb-cylinder, and is itself stripped by the brush *H*, the latter returning the wool to the large cylinder *K*, which then carries it forward to and against a steel blade or straight edge placed vertically at a very small distance from the comb-cylinder; the latter draws the wool through the narrow slit, but every bur, seed, or other foreign substance, is stopped by the plate. A roller *l*, covered with spiral blades, revolves against the plate, and carries off the arrested burs, together with any locks of wool which may be attached to them, and throws them back to the cylinder *M*, the teeth of which throw them back over the bars of a grating to a small fluted roller *N*, which delivers the lock of wool — by this time detached from the bur — down the sloping board.

The wool which has passed the opening at the plate is carried on by the combs till it is stripped off by the brushes fixed in the angles of a large prismatic roller *L*, which delivers it down the inclined exit-board.

Bur'ring-saw. A serrated wheel or blade which works in a burring-machine to seize the fibers of wool and draw them away from the burs, which cannot pass the opening through which the saw works.

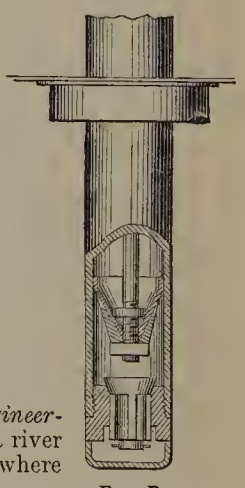
Bur'ring-wheel. A circular or annular wheel with serrated periphery, used in burring wool or ginning cotton.

Fig. 994.



Burring-Wheel.

Fig. 995.



Burr-Pump.

Bur'rock. (*Hydraulic Engineering.*) A small weir or dam in a river to direct the stream to gaps where fish-traps are placed.

Burr-pump. (*Nautical.*) A form of bilge-water pump in which a cup-shaped cone of leather is nailed by a disk (burr) on the end of a pump-rod, the cone collapsing as it is depressed, and expanding by the weight of the column of water as it is raised.

Burst'ing-charge. 1. (*Mining.*) A small charge of fine powder, placed in contact with a charge of coarse powder or nitroleum to ensure the ignition of the latter. It is usually fired by voltaic means.

2. (*Ordnance.*) The charge of powder required for bursting a shell or case-shot; it may be poured in loose, or placed in a *burster-bag*.

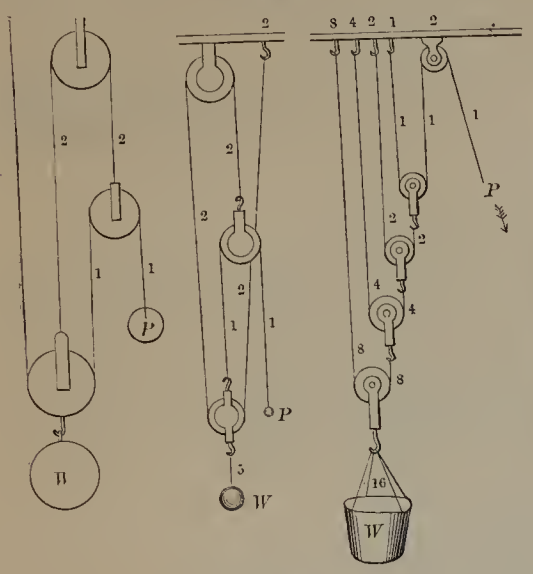
Bur'ton. A peculiar style of tackle. It has at least two movable blocks or pulleys and two ropes. The weight is suspended to a hook-block in the bight of the running part.

This arrangement of cords and pulleys is susceptible of great variation, so as to increase in a twofold, fourfold ratio, or otherwise. Each pulley has but one sheave, and there are as many ropes as movable pulleys. The numbers indicate the relative tensions of different cords. (Fig. 996.)

Bur'ton-tack'le. An arrangement of pulleys. See BURTON.

Burt's Nip'pers. An instrument used for keeping the line perpendicular in deep-sea soundings. It is suspended from a bag which floats on the surface, and the sounding-line is passed between a plate or spring and a roller, which allow it to run freely through in descending, but "nip" it when it strikes

Fig. 996.



Spanish Burton.

bottom and stops running or is pulled backward. It thus also indicates the precise up-and-down depth of the sounding.

Bush. (Fr. *bouche*, a mouth.) A bearing for a spindle or arbor, as in the case of the wooden chocks; called also *followers*, which surround the spindle within the eye of a bed-stone, and form the upper bearing of the spindle. A piece of metal or wood inserted into a plate to receive the wear of a pivot or arbor.

A *thimble*, *sleeve*, or hollow socket placed in a hole in a plate or block, and adapted to receive a spindle, gudgeon, or pivot. It forms a lining for a bearing-socket.

Old and worn pivot-holes are bored out, bushed, and a new pivot-hole drilled. The collar of a lathe-spindle is a bush. Gun-vents are bushed. Bush-metal is a bronze — copper and tin — used for journals.

The pivot-holes of the old-fashioned wooden clocks were bushed with box or pear-tree wood. Dogwood or apple-tree wood also affords good material for wooden bushing.

The circular guide in which a rod slides.

A circular piece of metal let into the sheaves of such blocks as have iron pins.

A collar around a piston-rod or a bearing in a shaft-hanger is sometimes called a bush. See Bushing.

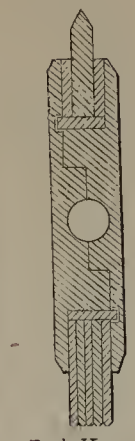
Bush-ex-tract'or. (*Husbandry.*) An implement for pulling out bushes and grubs. It usually consists of a lever having at its lower end a claw, clevis, or grapple, which pinches the stem of the bush against the lever, and then, the lever being depressed by rocking on its rolling shoe or axle, the latter forms the fulcrum, and the grub is torn up by the roots. It is of the nature of a claw-bar or cant-hook, or a pair of claws.

Bush-ham'mer. 1. The mason's large breaking-hammer.

2. The miller's hammer for dressing millstones. The steel bits are usually detachable from the sockets of the heads, to enable them to be dressed on a grindstone.

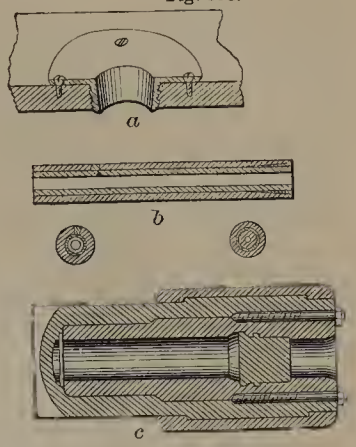
In the example the frame is made of two parts, with shoulders, and with cavities for bolts, and projections from the base for the support of the cutters which are socketed therein.

Fig. 997.



Bush-Hammer.

Fig. 998.



Bushings.

Bush-har'row. An agricultural implement consisting of a number of limbs or saplings confined in a frame and dragged over ground to cover grass-seed.

Bush'ing. A lining for a hole. Often called a Bush (which see).

a is a bushing for the bung-hole of a barrel.

b is a bushing to reduce the caliber of a gun-barrel; a taper tube is brazed in place at the end between the two, and makes all fast.

c is a breech-loading cannon, having a bushing secured by joint-screws and a reïnforce on the exterior.

d is a metallic hub with an inner bushing to form the axle-box.

Bush-scythe. A stout short scythe for cutting brush and briers.

Busk. A stiffening bone or plate in a corset, to maintain its shape and prevent its gathering in folds and wrinkles around the waist. The busk is made of wood, steel, brass, whalebone, or vulcanite.

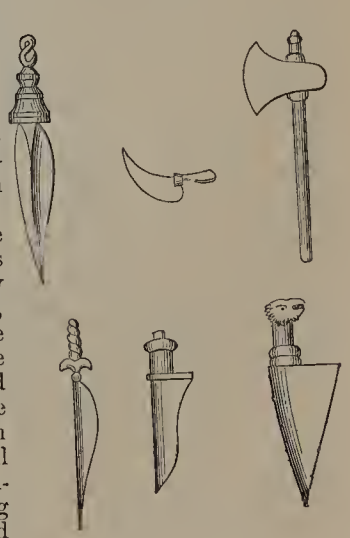
Buss. (*Vessel.*) A two-masted fishing-vessel of from 50 to 70 tons burden. It has a cabin at each end.

"They have a designe to get the king to hire a docke for the herring busses to lie up in." — Pepys, 1661.

Bust. A statue of the upper part of the person, embracing the head, shoulders, and breast.

Lysistratus, the sculptor, is cited as the inventor of casting busts, etc., from molds, 328 B. C. Busts from the face in plaster of Paris were first taken by Andrea Verocchi, A. D. 1466. The plaster cast is made by pouring the fluid plaster around the head and face, which are previously well oiled, to prevent adhesion, the hair being protected by an oiled cap. When the plas-

Fig. 999



Roman Knives, etc.

ter has partially set, and while it is yet in a soft state, the mold is divided into sections for removal by strings or fine wires previously arranged in the interior. Busts are now turned by machinery constructed on the principle of Blanchard's lathe for turning irregular forms, which was originally applied to turning gun-stocks and spokes for carriage-wheels.

Butch'er-knife. A knife for cutting meat. The tang of the blade is usually riveted between two *scales*, which form the handle.

The Roman butcher-knives, used also for sacrificial purposes, were wide at the hilt-end of the blade, and had sharp points. The pole-axe is also shown in the figure.

Next to the pole-axe is the *seva* or *secespita*, for cutting the throats of the animals. On the left is the *dolabra*, for dismembering. Below are the *cultri* or *cultelli*, for skinning and slicing.

But'ment-cheek. (*Carpentry.*) The part of a mortised timber surrounding the mortise, and against which the shoulders of the tenon bear.

Butt. The hinder, larger, or blunter end of an object; as of a gun, a connecting-rod, a crow-bar, etc.

1. The end of a *connecting-rod* against which the *boxing* is attached by the *strap*, *cotter*, and *gib*.

2. The end of an object where it comes squarely against another.

3. A joint where the ends of two objects come squarely together without scarfing or chamfering.

4. A form of door-hinge which screws to the edge of a door, and *butts* against the casing instead of extending along the face of a door, like the *strap*-hinge. It consists of two oblong plates, one edge of each of which is dentated to fit its fellow, a *pintle* traversing each interlocking portion to form a joint. See BUTT-HINGE.

5. *a*. A target.

b. A wooden structure, consisting of several thicknesses of boards, separated by small intervals, for the purpose of ascertaining the depth of penetration of bullets.

c. A frame of iron and wood, representing a large section of armor-plating, and moored in position for determining the destructive power of shot, shell, and given charges of powder.

d. A mound of earth to receive the bullets in the proof of gun-barrels.

6. (*Shipbuilding.*) The meeting-joint of two *planks* in a *strake*. The joint between two strakes is a *seam*.

7. The thick part of an ox-hide.

8. The standing portion of a half-coupling at the end of a hose.

9. The shoulder-end of a gun-stock covered with a heel-plate.

10. A large cask containing 126 wine gallons.

Butt-chain. (*Saddlery.*) A short chain which reaches from the leather tug to the single-tree, to each of which it is hooked.

But'ter. 1. (*Wood-working.*) A machine for sawing off the ends of boards, to render them square and to remove faulty portions.

In the large saw-mills of the lumber-regions double butters are used, one saw being permanent and the other adjustable by a spline on a grooved mandrel, to adapt it for boards of varying lengths. The boards are laid upon parallel, traversing, endless chains, with dogs at intervals.

2. See CHURN.

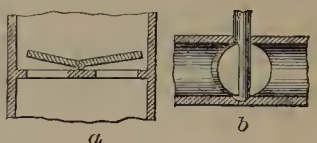
But'ter-fly-cock. A valve having two semicircular wings pivoted on a central cross-bar. A butterfly-valve.

But'ter-fly-valve. A double clack-valve, each leaf of which is hinged to a bar crossing the passage-way, as in the examples annexed.

a, butterfly pump-valve.

b, butterfly throttle-valve.

Fig. 1000.



a *b*

Butterfly-Valves.

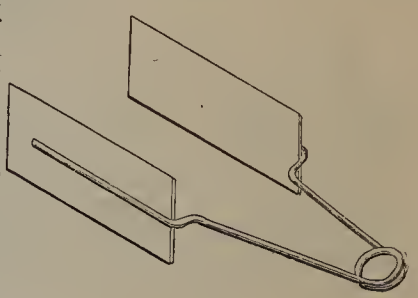
But'ter-is. (*Farriery.*) A knife with a bent shank, used by blacksmiths to pare the hoofs of horses. It has a blade like a chisel, and is operated by a thrust movement, the handle resting against the shoulder.

The term is probably from the French *boutoir*; Provincial, *boutavan*. Some old Roman paring-implements of iron are yet extant.

But'ter-mold. (*Husbandry.*) An implement by which pats of butter of a given size are shaped and printed for market.

Butter-tongs. An implement for cutting and transferring pieces of butter. In Fig. 1001 the blades are attached to shanks which unite in a spring coil, so as to separate them when not in actual use.

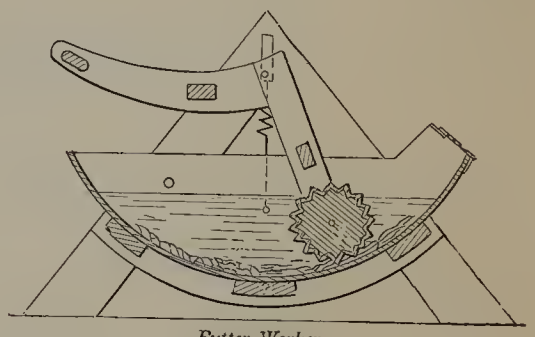
Fig. 1001.



Butter-Tongs.

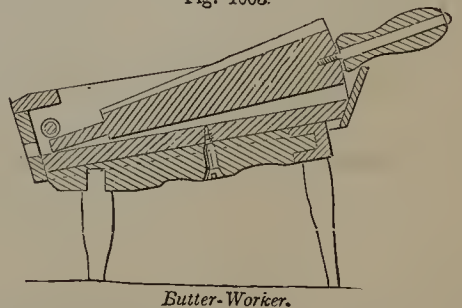
But'ter-work'er. (*Husbandry.*) An implement for pressing and rolling butter to free it of the buttermilk. It may be a fluted roller working in a bowl or on a board, or a conical roller on a slanting board which permits the buttermilk to run off.

Fig. 1002.



Butter-Worker.

Fig. 1003.



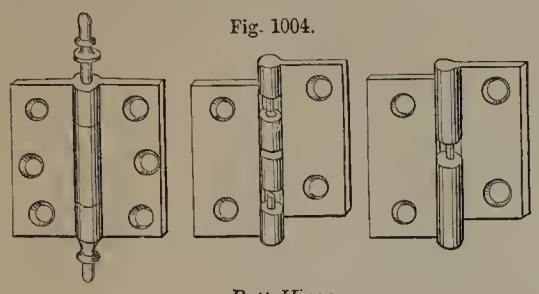
Butter-Worker.

Butt-how'el. (*Coopering.*) A howeling-adze used by coopers.

Butt-hinge. A hinge formed of two plates and interlocking projecting pieces which are connected by a *pintle*.

The *butt*-hinge is so called because, instead of fastening on the faces of the door and jamb like the

Fig. 1004.



Butt-Hinge.

ancient hinges, the leaves are secured to the door and casing at points which *abut* upon each other.

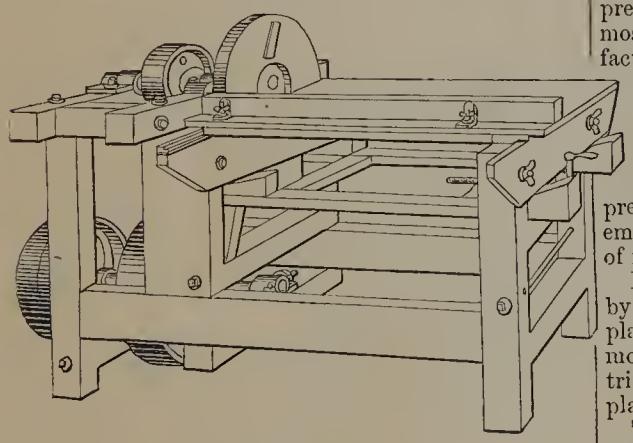
A *rising butt* is one in which the leaf attached to the door ascends as the door is opened, an incline on one leaf climbing on the incline of the part it rests on, so as to give to the door a tendency to descend and close in so doing.

The following names are known in the trade: —

Broad butts.	Wrought-butts.
Narrow butts.	Table-butts.
Loose-joint butts.	Fast-joint butts.
Reversible butts.	Acorn-tipped butts.
Shutter-butts.	Congress-butts.

But'ting-ma-chine'. A machine having planing-cutters on the face of a disk-wheel, and used for smoothing, cornering, or rounding the ends of joists

Fig. 1005.

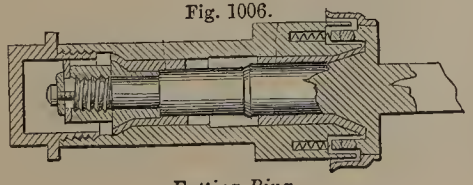


Butting-Machine.

or small timbers used in the frames of agricultural implements, etc. The stuff is laid alongside the fence or gage, and is fed up endwise to the cutter.

But'ting-ring. (*Vehicle.*) A collar on the axle against which the hub *butts*, and which limits

Fig. 1006.



Butting-Ring.

the inward movement of the wheel, as the linch-pin or axle-nut does the outward. In the example, a butting-flange on the axle enters a groove in the inner end of the box, and abuts against springs whose elasticity lessens the jar when the wheel plays longitudinally on its spindle.

But'ting-saw. A cross-cut saw attached to a stock at one end, and used for butting logs on the carriage of a saw-mill. Many logs are brought to the mill with the slanting kerf given by the axe in felling or logging. To *butt* a log is to cut or saw it off square at the end, so that it may lie safely upon the rabbet of the head-block in any position, and be readily held by the dogs. The action of this saw is that of a *drag*-saw.

Butt-joint. A joint in which the pieces come square against each other, endwise. In iron work the parts are welded, and the term is used in contradistinction to a *lap*-joint or weld.

But'tock. (*Shipbuilding.*) The rounded-in, overhanging part on each side and in front of the rudder; terminating beneath by merging into the *run*.

But'tock-lines. The curves shown by a vertical longitudinal section of the after-part of a ship's hull, parallel to the keel. A similar section forward exhibits the *bow*-lines, and a continuous section through the whole length of the ship the *buttock* and *bow lines*.

But'ton. 1. A small circular disk or knob with a shank for attachment to an object, and forming, in concert with an opening in another object, or another side of the same, a means of fastening the two together.

The ancient modes of fastening dresses were pins, brooches, buckles, and tie-strings.

Iron, steel, brass, copper, pewter, lead, gold, silver, horn, shell, pearl, tortoise-shell, ivory, bone, hoofs, hair, silk, cotton, linen, Florentine, gutta-percha, india-rubber, vulcanite, amber, velvet, cloth, glass, porcelain, wood, enamel, jet, compressed earth, clay, precious stones, are among the most prominent substances employed in the manufacture of buttons.

Buttons of brass are noticed on dresses of the tenth century. About 1670 the metallic button-manufacture of England took its rise.

A manufactory was established in Birmingham, England, 1689, and that city still maintains a preëminence in this manufacture, as in so many others, employing no less than 4,981 persons in this branch of industry alone, according to the census of 1851.

Metallic buttons with shanks are usually made by punching the disks forming their faces out of a plate of sheet brass containing less zinc than common brass; the edges of the disks are afterwards trimmed to remove the bur, and their faces are planished under the action of a hammer.

The maker's name is stamped on the back and the face embossed at one operation, by means of cameo and intaglio dies.

The shanks are made of wire by a machine; a shears cuts off a piece of suitable length from the coil; a stud then presses against the middle of the cut piece, and forces it between the jaws of a vice, which give it a staple-like form, compressing it so as to form the eye of the shank; it is then struck by a small hammer, which makes it level, and another movement drops it into a box.

The shanks are then placed in their proper positions on the disks, being retained by a bent, flat strip of iron, a piece of solder being placed at the foot of each shank. A hundred or more are then put on an iron plate and heated in an oven until the solder melts, fixing the shank and forming a

backing to the button. They are then turned separately in a lathe adapted for the purpose, and, if desired, gilt, which operation was, previous to the electro-plating process being perfected, performed by coating the brass disk with an amalgam of mercury and gold, the former of which was afterward driven off by heat.

When the face only is gilt, the buttons are technically known as *tops*, but when gilding is applied to the whole surface they are termed *all-overs*. The gilding, though extremely thin, admits of being brightly polished by means of an agate or bloodstone burnisher.

Gilt buttons first made by Taylor, of Birmingham, England, 1768. Manufacture improved, 1790.

Metallic buttons without shanks are formed by stamping; those of wood, bone, etc., are turned; the holes, of which there may be two or four for attaching the button to the garment, are drilled while the button is in the lathe by means of four long drills converging toward the button, forming all four of the holes at once.

Cast buttons are made by taking a large number of impressions in a mold and inserting in each the loop of metal, whose expanded ends project into the mold and are surrounded by the metal of the button. The buttons, being cleaned from the sand, are chucked and turned, when they may be tinned, silvered, or gilded, as required.

Papier-maché buttons were made in 1778.

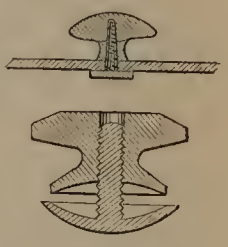
Mother-of-pearl buttons are cut out of the shell by means of a small cylindrical saw. The disks are turned in a lathe, and if the shell be sufficiently thick it is split so as to form two buttons. A dovetail hole is drilled for the shank, which is fixed by a slight blow with a hammer, its lower part expanding into the dovetail, so as to prevent its being readily withdrawn. The ornamental flutings and corrugations when present are formed in the lathe by means of an eccentric chuck and slide-rest.

A number of patents for making covered buttons, which are in such extensive use for outer garments, have been taken out in England since the first patent of Sanders in 1809; but the general principles of construction of the more important kinds may be reduced to two: in one of these a metallic disk or *shell* is stamped out of thin sheet-iron, for the face part, and a smaller *disk* or *collet*, having a perforation for the shank to pass through, is stamped out in like manner for the back. A circular piece of the textile fabric to be used is cut out by a die, and a pad of similar shape, commonly made of soft paper, silk, and thread is formed, which fills up the vacant space between the two metallic disks. The parts — namely, the two disks, the pad and the circular piece of linen, silk, or other material forming the face — are united to constitute the finished button by means of a stamping-press and appropriate convex and concave dies. The shank, of soft material through which a needle can be passed, protrudes at back through the aperture in the collet.

In the other plan, the disk for the body is left flat, and the back piece is a small circular disk with a round hole in its center, and having its edge cut into eight sharp triangular points, which are so bent as to form nearly a right angle with the disk, inclining slightly inward. To complete the button three pieces of paper and two pieces of cloth are necessary, which are arranged in the following manner.

On the piece of cloth forming the outer covering is laid a piece of paper of the same size, upon which is placed the iron disk forming the body; on this is another piece of paper the same size as the body; on this is a small pellet of paper to help form the shank; a piece of coarse cloth is laid on this, and the metallic back placed over it. In putting on the back, the cloth is gathered up over the whole of the materials and the points of the back pressed into the cloth; as these are bent slightly inward, the pressure causes them to bend still more as they enter the cloth, forming eight little hooks, which hold the button together in a neat and effectual manner; the paper pellet causes the cloth to protrude through the hole in the back, forming the cloth shank by which the button is sewed to the coat.

Fig. 1007.



Self-Fastening Buttons.

Fig. 1007 shows two forms of self-fastening buttons, having screws which pass from the rear of the material into the shanks.

2. (*Carpentry.*) A small piece of wood or metal, swiveled by a screw through the middle, and used as a fastening for a door or gate.

A knob on a sliding-bolt.

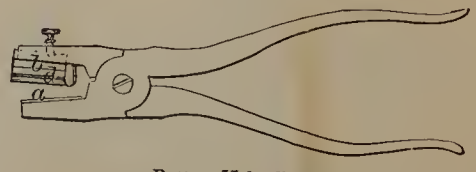
3. (*Metallurgy.*) A globule of metal remaining in the cupel after fusion.

But'ton-brace. A tool for making buttons. The handle is like the common brace; the bit has cutters, but no router, and removes a circular blank or planchet of bone, pearl, wood, or whatever the material may be; an *annular bit* operating like a crown-saw or trephine.

But'ton-hole Cut'ter. A device on the shears principle, specially adapted for cutting button-holes; the variations in construction principally relate to means for adjusting the length of the cut, and its angle with the edge of the cloth.

In Fig. 1008, the cutter *d* may be approached toward the center of motion, so as to cut its whole

Fig. 1008.



Button-Hole Cutter.

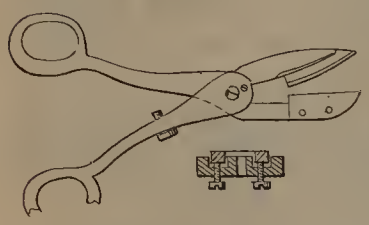
length, or projected outwardly so that its edge may only partially bear against the jaw *a*, to make a shorter cut.

But'ton-hole Sew'ing-machine. In working button-holes by machinery, it is common for the perforating-needle to descend first through the material back from the slit, and then through the slit, or else a thread may be carried from the under side up over the edge of the material, and be locked by the needle in its next descent. The needle may be made to descend through the material and through the slit, by moving the material laterally, as well as forward by the feed, as in patent to Miller, March 7, 1854; or the needle-carrying box may be moved laterally after each stitch, by means of a cam, as in patent to Humphrey, October 7, 1862. The needle-thread is locked at each descent by a second thread carried by either a looper or a shuttle. In patent to Sleiner, June 19, 1860, the needle and shuttle operate as in an ordinary machine, but after the shuttle has passed through the loop of needle-thread, a hook catches its thread and passes it in the form of a loop up through the button-hole slit and spreads it in the path of, and the needle enters it at its next descent.

In patent to Rehfuss, May 23, 1865, the needle descends through the material back from the slit, a looper passes its thread through the loop of needle-thread, and then passes up through the slit, where its loop is caught by a hook, and spread in the path of the needle, which enters it at its next descent. Other methods of working button-holes have been attempted, but not found practicable.

Button-hole Shears. A scissors having an adjustability for length of cut, for the purpose of cutting button-holes. In one example, a set screw on one part of the shears bears against a washer on the other portion, to regulate the relative lateral adjustment of the two parts.

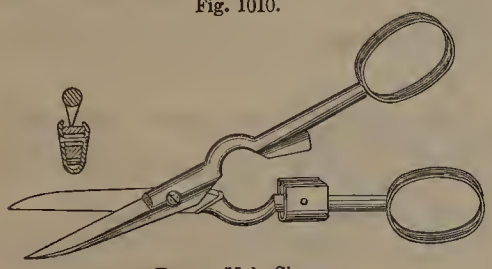
Fig. 1009.



Button-Hole Cutter.

In the other example, the button-hole cutter is attached to the shank of the shears.

Fig. 1010.



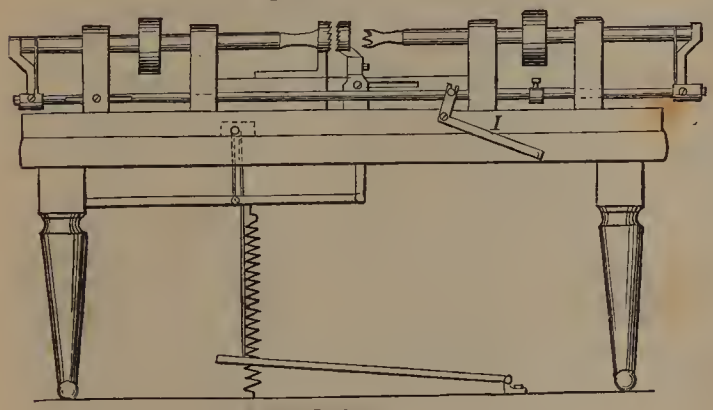
Button-Hole Shears.

But'ton-hook. A hook for grasping a button below the head, in order to draw it through the button-hole and fasten it.

But'ton Key or Fas'ten-er. A spring loop, the free ends of which, being passed through the shank of a button, expand so as to hold the loop in position and keep the button in place. A piece of coiled wire, making two or more turns, is also used for this purpose.

But'ton-lathe. A machine for cutting round disks for buttons. The material consists of plates of horn, bone, ivory, wood, mother-of-pearl, etc. The

Fig. 1011.



Button-Lathe.

cutter is like a center-bit, except that both of the wings are *cutters*, and not one of them a *router*. The tool revolving, the center-pin transfixes the stuff, and the wings make a circular cut, cutting out a disk of the material, which is advanced to the cutter by a sliding bar in the back poppet-head.

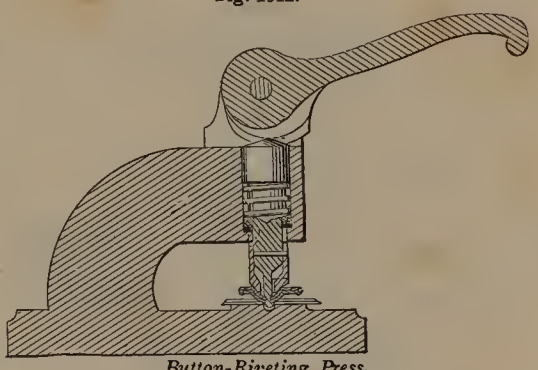
In the example, the moving jaw of the clutch is forced against the blank by a spring, and drawn back by depression of the treadle. The bits are brought singly and alternately against the blank, being moved thereto by the bell-crank hand-lever.

But'ton-loom. (*Weaving.*) A loom for weaving button-blank coverings.

But'ton-mold. A disk of bone, wood, or metal, to be covered with fabric to form a button.

But'ton Riv'et-ing-ma-chine'. A tool for fastening buttons to garments by swaging down on the back of the washer the end of the rivet which forms the shank of the button. In the example the

Fig. 1012.



Button-Riveting Press.

plunger is pointed, rotates as it descends, and spreads the end of the rivet. A sleeve on the plunger fits the hollow in the face of the button, and the flanged head of the rivet is bent over toward the fabric, which is thereby clamped against the convexity of the button.

But'ton-tool. A tool for cutting out buttons or circular blanks therefor. An annular bit. See BUTTON-LATHE.

But'tress. 1. (*Masonry.*) *a.* A pier or lean-to pillar on the exterior of a wall, to enable it to withstand an interior thrust, as in the case of a retaining or breast wall.

b. A flying buttress is one which is in the form of a section of an arch, springing from a wall or pillar.

2. (*Fortification.*) A counterfort or sustaining wall or pillar, built against and at right angles to the wall to which it forms a revetment. See COUNTERFORT.

Butt-weld. (*Forging.*) A weld in which the edges are square-butted and jammed against each other, and then welded. A *jump-weld.*

Buzz-saw. Another name for the circular saw, derived from the buzz or hum incident to the high speed at which it is run. See CIRCULAR SAW.

By'ard. (*Mining.*) A leather breast-strap used by miners in hauling the wagons in coal-mines.

Bye-wash. (*Hydraulic Engineering.*) *a.* A channel to divert past a reservoir water of streams which would otherwise flow with it, and which are impure or otherwise undesirable. Called also a *diversion-cut.*

b. The outlet of water from a dam. A *waste.*

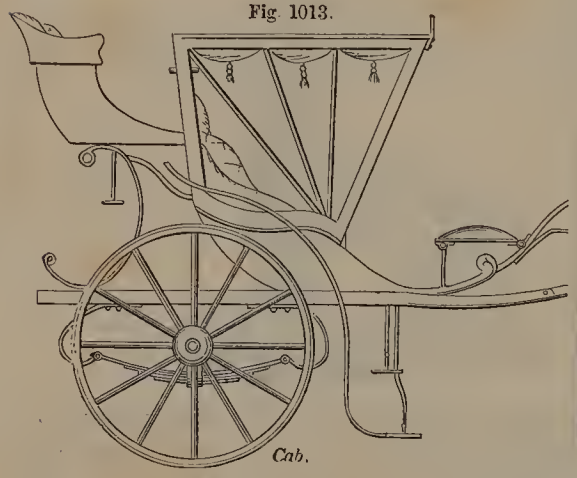
Bys'sa. (*Fire-arms.*) An ancient form of cannon for throwing stones.

C.

Caam. The weaver's *reed*. The *sley* or *slaie*. *Caaming*, the *setting* of the *reed* by the disposing of the warp-threads.

Cab. 1. A two or four wheeled, one-horse, closed vehicle, adapted to seat two persons inside, and having an elevated seat for the driver in front. The hanson-cab has a seat behind for the driver. The cab of Pickwick's time had two wheels and an outside seat on the right side, over the wheel. In the one shown, the driver's seat behind the body of the

Fig. 1013.



Cab.

cab rests on a spring, and is supported on the rear extension of the frame of the vehicle. It has a supplementary seat next the dash-board, and also an opening in the back of the cover to permit communication between the driver and passenger.

Cabs were introduced into London for hire, 1823. Fifty were first started; there are now 7,000 in that city.

2. The covered part in front of a locomotive which protects the engineer and fireman, and shields the levers, etc.

Cab'bling. (*Metallurgy.*) A process of breaking up pieces of flat iron, to be fagoted, reheated, and rolled.

The series of processes are as follows: —

1. The pig-iron is treated in a refining-furnace.
2. The *loop* is forged.
3. Melted in contact with charcoal, and worked with a *rabble*.
4. *Tilted;* making a flat, oval plate.
5. *Cabbled;* that is, broken up into pieces.
6. *Fagoted*.
7. Reheated in a reverberatory furnace.
8. Hammered.
9. Rolled.

Ca-be'ca. (*Fabric.*) The finest kinds of India silk, as distinguished from the *bariga*, or inferior kind. *Cabesse*.

Cab'i-net-file. A smooth, single-cut file, used in wood-working, especially by furniture-makers and joiners.

Cab'i-net-or'gan. (*Music.*) A superior class and size of reed organ.

Ca'ble. 1. The strongest kind of rope, chain, or cluster of wires designed for holding a ship at anchor, for supporting the roadway of a suspension-bridge, for mooring, warping, and for other purposes.

Cables for supporting suspension-bridges were formerly made of a number of wire ropes, each of which consisted of wire twisted into strands. Suspension-bridge cables are now made of separately stretched steel wires, each of which is brought to a certain strain, and the bunch bound up into a cable, wrapped, parceled, and then served with wire and painted.

Submarine cables for telegraphic purposes have an interior core of copper wire surrounded by wires twisted after the manner of a rope, the whole being protected by a non-conducting waterproof coating of gutta-percha or india-rubber.

A large cable-laid rope is thus made: —

Hemp is laid up *right-handed* into *yarns*.

Yarns are laid up *left-handed* into *strands*.

Three *strands* are laid up *right-handed* into a *hawser*.

Three *hawsers* laid up *left-handed* make a *cable*.

See Rope.

Below ten inches in circumference, a rope is called a hawser.

Cables or ropes are —

Served; bound with rope, marline, or other small stuff, to prevent chafing.

Spliced; united by working the yarns or strands of the two portions together.

Parceled; wrapped with tarred canvas.

Wormed; having the spiral crevices between the lays filled with strands; usually a preliminary to *serving*.

A *cable's length* is 120 fathoms = 720 feet.

A *stream* cable is a hawser for mooring.

To *bit* the cable, is to wind it around the *bitts*.

To *buoy* the cable, is to support it by floats which keep it clear of the ground in a rocky anchorage.

To *coil* the cable, is to dispose it in helical tiers.

To *cut* the cable, is to sever it by an axe, or by unshackling, in *club-hauling* or to save the time necessary for *weighing*.

To *drag* the cable, is to haul it in the wake of the vessel.

To *fleet* the cable, is to allow it to surge back on the *whelps* of the capstan or windlass, as the cable climbs on to the larger part of the cone.

To *heave* the cable, is to haul in aboard.

To *nip* the cable, is to stop the running out by a pinching-rope, clamp, or lever.

To *pay out*, is to allow the cable to run out.

To *serve* the cable, is to wrap it with ropes to keep it from being chafed.

To *slip* the cable, is to let it run clear out, thus losing the cable.

To *stopper*, to fasten to the bitts.

To *unbend*, to detach from the anchor.

To *underrun;* with hempen hawsers, to take on board on one side of a boat and pay out on the other, examining and cleansing.

To *veer* a cable, to allow it to run out, keeping command over it.

A *kink* is a short turn in a cable which prevents its running through the hawse-hole.

Ships' cables were anciently made of flax, papyrus, or spartium; more lately of hemp or coir, but now usually of iron links.

A hempen cable of 12 inches girth and 120 fathoms (720 feet) long, weighs 3,075 pounds.

The weight of a hempen cable (120 fathoms) may

be ascertained by multiplying the square of the girth in inches by 21. The product is the weight in pounds, nearly.

The breaking-strain may be found by dividing the weight in pounds by 100; this gives the breaking-strain in tons.

2. A molding representing a cable or spiral scroll.

Ca'ble-buoy. (*Nautical.*) A floating object secured by a rope to an anchor, to denote the position of the latter.

Ca'ble-grip'per. A lever compressor over the cable-well, and by which the cable is stopped from running out.

Ca'ble-hook. 1. A hook for attachment to the *messenger* by which the cable is hauled in on a man-of-war, or other ship having a large number of hands, without having recourse to the capstan. It may also be attached to a hawser, for underrunning the cable.

2. A hook by which the cable is handled. Each seaman has a hook in *lighting-up* the cable or packing in tiers.

Ca'ble-laid. Heavy rope, laid up cable-wise. See CABLE.

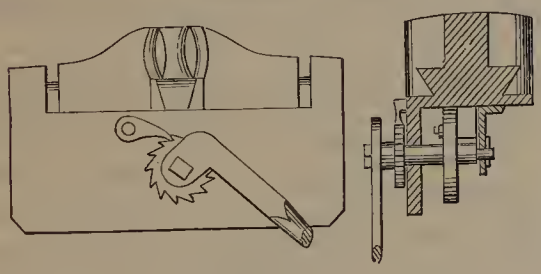
Ca'ble-mold'ing. A bead or torus molding, cut in imitation of the twisting of a rope, much used in the later period of the Norman style.

Ca'ble-nip'per. (*Nautical.*) A device serving to bind the *messenger* to the cable, and composed of a number of rope-yarns or small stuff marled together.

Ca'ble-shack'le. A D-shaped ring or *clevis*, by which one length of cable is connected to another, or, upon occasion, the cable connected to an object, such as the anchor-ring.

Ca'ble-stop'per. (*Nautical.*) A device to stop the paying out of the cable. In the example, a

Fig. 1014.



Cable-Stopper.

pair of jaws slide on the rail, being moved simultaneously by an eccentrically slotted wheel and a lever.

The rope is passed around the pin and clamped by both jaws.

Ca'ble-tier. (*Nautical.*) *a.* A coil of a cable. A *fake;* one layer of cable as it lies in a tier.

b. A cable-locker.

Ca'bling. (*Architecture.*) A round molding, frequently used in the flutes of columns, pilasters, etc.

Ca-boose'. 1. (*Nautical.*) A small house on deck in which the cooking is done on a merchant-vessel.

2. (*Railway Engineering.*) A car attached to the rear of a freight train, fitted up for the accommodation of the conductor, brakemen, and chance passengers.

Cab'ri-o-let'. A vehicle for hire introduced from France into England in 1823. Shortened into *cab* (which see).

Cab'urn. (*Nautical.*) Spun rope-yarn for *seizing, worming,* and similar uses.

Ca-ca'o-mill. A mill for grinding the nut of the *theobroma cacao*, to reduce it to the condition of *flake cacao.* It differs from chocolate in being ground with a portion of its hull, instead of being carefully hulled before grinding. It is mixed in the hopper with flour, sugar, etc., and passed through a number of steel mills resembling paint-mills, by which the nut is reduced and the ingredients intimately incorporated therewith by means of friction, heat, and the oil evolved from the nut.

The *Theobroma cacao*, "Food for the gods," so named by Linnæus, from which cacao, broma, and chocolate are made, is grown in Caraccas, in the sheltered valleys, 500 feet above the level of the sea. The Mexican name is *cacauatl.* The tree is 20 feet in hight, and frequently planted with intermediate rows of coffee-trees, to shelter the young cacao-trees from the scorching heat. The crops are gathered in December and June, and a well-bearing tree will produce from 20 to 30 pods, which are gathered in a period of three weeks or so, as they turn yellow. After being allowed to lie in heaps for a time to farther ripen, the pods are opened, the pulp removed, and the beans spread on mats in the sun. As they dry, each obtains a hard, thin skin, and is of the size of a kidney bean. The next processes are those of the manufacturer, who commences by roasting the nuts and removing the husks.

Ca-cha-ra'do. (*Fabric.*) A kind of Spanish linen.

Ca-dene'. A common kind of carpet, imported from the Levant.

Cad'mi-um. Equivalent, 56; symbol, *Cd.*; specific gravity, 8.65; fusing-point, 450° F. A white metal resembling tin in appearance and zinc in properties.

Its use is as an ingredient in alloys.

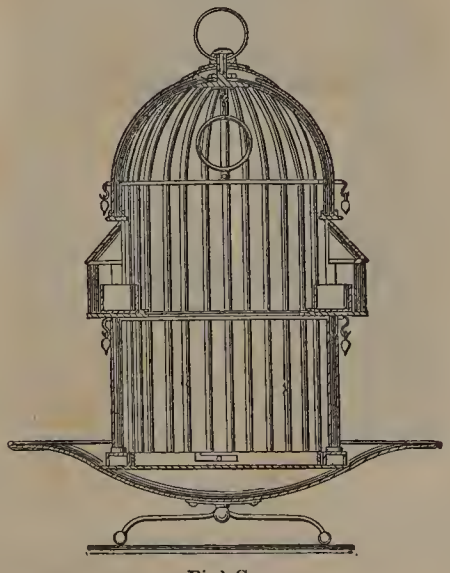
Cad'rans. An instrument for measuring the angles in cutting and polishing gems. See ANGULOMETER.

Caf'fa. (*Fabric.*) A kind of painted cloth goods manufactured in India.

Cag. A small cask used for packing herrings and other provisions. A *keg.*

Cage. 1. The prison of a bird or other animal. It is usually made of wire, sometimes of wicker, slats, splints, or strips of metal.

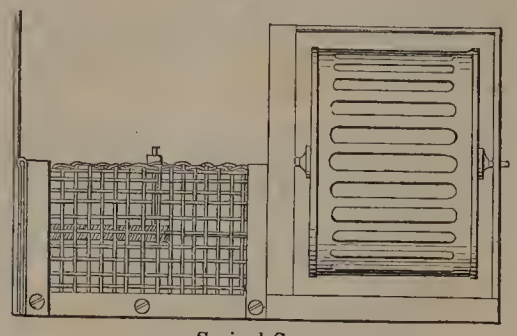
Fig. 1015.



Bird-Cage.

Those for squirrels or mice have usually a dormitory at one end, and a cylinder in which the animal is supposed to amuse himself by running without making any progress. In the example, the bars of

Fig. 1016.



Squirrel-Cage.

the tread-wheel are made by cutting slots in a sheet of metal subsequently bent to a cylindrical shape.

2. (*Mining.*) *a.* The platform on which trundles or hutches are raised or lowered in a shaft.

In coal-mining, the *hutches* or low-wheel cars are loaded and brought to the foot of the shaft, where from one to four are placed on the cage to be elevated. Arrived at the top, the cage rests on the folding-boards, which open before it and then shut automatically beneath it. The *hutches* are then run off, dumped, and returned to the cage, to be lowered again. See HOISTING-MACHINE.

Provision is made to stop the cage in case of the breaking of the hoisting-rope, and also to prevent its over-winding.

The safety-cage shown in Fig. 1017 runs on vertical guides, and has a cover to protect the men from falling objects. It has a spring *f*, which bears down the rod *e* to which the rope is attached. In case the

Fig. 1017.

Safety-Cage.

hoisting-rope breaks, the spring forces apart the two jaws *c c*, whose claws catch into the wooden guide-bars *d d*, and arrest the downward course of the cage. *b b* are coal-hutches on the platforms *a a* of the cage, and the illustration shows the rope as broken and the descent arrested.

b. The trundle-wheel of a whim on which the rope is wound. Also called a *drum* or a *turntree.*

3. (*Machinery.*) *a.* A skeleton frame to confine a ball-valve within a certain range of motion.

b. A wire guard placed over an eduction-opening, to allow liquid to pass, but restrain the passage of solids.

4. (*Carpentry.*) An outer work of timber for inclosing another work, as the cage of stairs.

Fig 1018.

Animalcule-Cage.

5. For microscopic objects in water, a cup having a glass bottom and cover, between which a drop of water containing animalculæ, or other minute objects, is placed for microscopic examination, in order to prevent their escaping beyond the focus of the microscope.

Ca-hier′. (*Bookbinding.*) A pile of gathered sheets; the successive numbers of a serial.

Ca-ique′. A boat used on the Bosphorus.

Cais′son. 1. A carriage accompanying a field-piece to carry ammunition, and participating with it in its maneuvers, forming in line in the rear of its piece when the latter is in action. The name *caisson* is also applied to an ammunition-chest. See GUN-CARRIAGE.

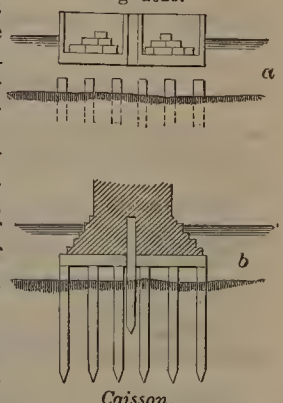
2. A water-tight structure or bag placed beneath a sunken vessel, and then either supplied with air by pumping out the water and allowing air to enter, or distended by air from an air-pump, so as to assist in floating the vessel.

3. A water-tight box or casing used in founding and building structures in water too deep for the coffer-dam; such as piers of bridges, quays, etc.

The caissons employed in building the piers of the railroad bridge over the Susquehanna at Havre de Grace, Md., are an example of the use in the first-mentioned capacity.

Caissons resting upon a river-bed subject to washing have proved to be unsafe, as was evinced at Westminster Bridge, where the caisson was undermined by the current; the structure was saved by sheet-piling and underpinning.

Fig. 1019.



Caisson.

The plan adopted by Peronnet and other eminent French architects was to drive a substratum of piles, which were sawn off to a level surface, forming a foundation for the structure which settled the caisson on its bed of piles as the masonry progressed. For the purpose of securing the coincidence of the caisson and its bed of piles, one of the latter was allowed to project upwardly, as high as the top of the caisson, occupying a well or water-tight curb which was open at each end. The long pile formed a guide, causing the caisson to settle correctly into position. The guide-pile has been occasionally used, but is by no means a necessary feature of the work.

When the work is concluded, the sides of the caisson are knocked away, leaving the pier in position, as shown in the illustration.

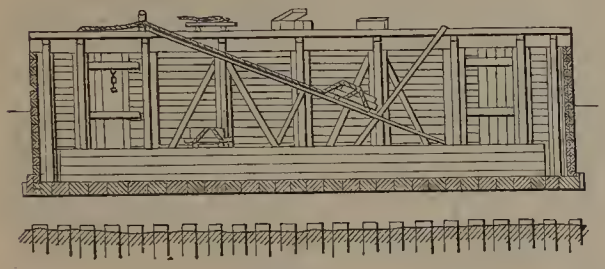
a represents the sinking of the caisson.

b, the pier on its foundation.

The caissons used by De Cessart in 1757 for the piers of the bridge at Saumur were sunk upon a foundation of piles, the heads of which were previously cut off to a level of about six feet below the water-surface. Each caisson was 48 × 20 feet, the ends being pointed and the sides removable, so that they could be used with another bottom after the masonry was laid nearly to the water-line. The bottom had a floor of lower beams laid side by side, and planks 14 inches thick, and the frame timbers were rabbeted to receive the uprights of the sides, which were secured to the bottom framing by dovetails and wedges, so that, the latter being withdrawn, the sides were disconnected.

The sides were 16 feet high, of scantling laid on edge and maintained in position by uprights, secured by struts and overhead braces, so as to resist the pressure of the water, and also by lap-joints and uprights at the angles of the caisson, the whole carefully calked. The caisson was built on the bank of the river upon piles cut to three different hights above the water; by blocking up, its bottom was kept level while building, and by removing these blocks, and with the aid of jacks, it was tilted so

Fig. 1020.



Caisson.

as to slide readily into the water, when it was towed into position, and the masonry laid until it sunk squarely on the heads of the piles previously driven for its reception.

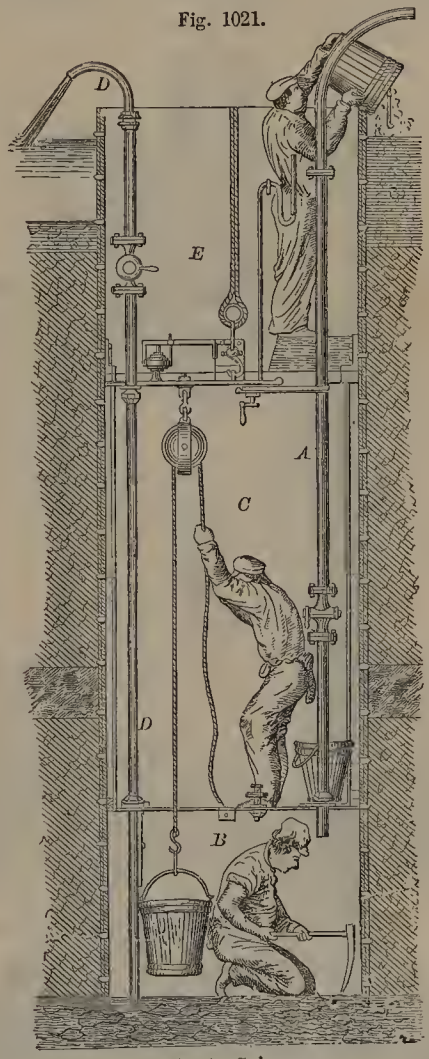
The modern or pneumatic caisson, which is sunk through quicksands or submerged earth or rock, is the invention of M. Triger, who contrived by the aid of air-pumps to keep the water expelled from the sheet-iron cylinders, which he sunk through quicksands in reaching the coal-measures in the vicinity of the river Loire, in France.

The seams of coal in this district of France lie under a stratum of quicksand from 58 to 66 feet thick, and they had been found to be inaccessible by all the ordinary modes of mining previously practiced.

Fig. 1021 illustrates the caisson of M. Triger, and shows the comparatively simple form which the apparatus assumed when used for sinking a simple shaft through a water-bearing stratum above the coal. Air is forced in through the pipe *A* to the working-chamber *B*, which has a man-hole in the floor above. *C* is the middle chamber, which has also a man-hole in its ceiling. *D* is a pipe by which sand and water are ejected from chamber *B*, under the pressure of the condensed air in the latter. The pressure of air in chamber *B* being such as to exclude the water, the workman descends through the man-hole in the floor of chamber *E* and closes the door behind him. Admitting air from chamber *B* until the pressure is equal in the two, he opens the door in the floor of chamber *C* and descends to his work. The buckets are similarly managed, the middle chamber *C*, acting as the means of communication, being filled with air at normal pressure, or with compressed air, according as it is in communication with the open air of chamber *E* or the condensed air of chamber *B*. The device which thus acts as an intermediate is termed an air-lock, and is the notable point of invention in the apparatus.

The cast-iron piles which support the arched bridge over the Medway at Rochester, England, were sunk by the means of compressed air, which kept them empty of water while workmen excavated the materials inside the piles. Each pier consists

Fig. 1021.



Triger's Caisson.

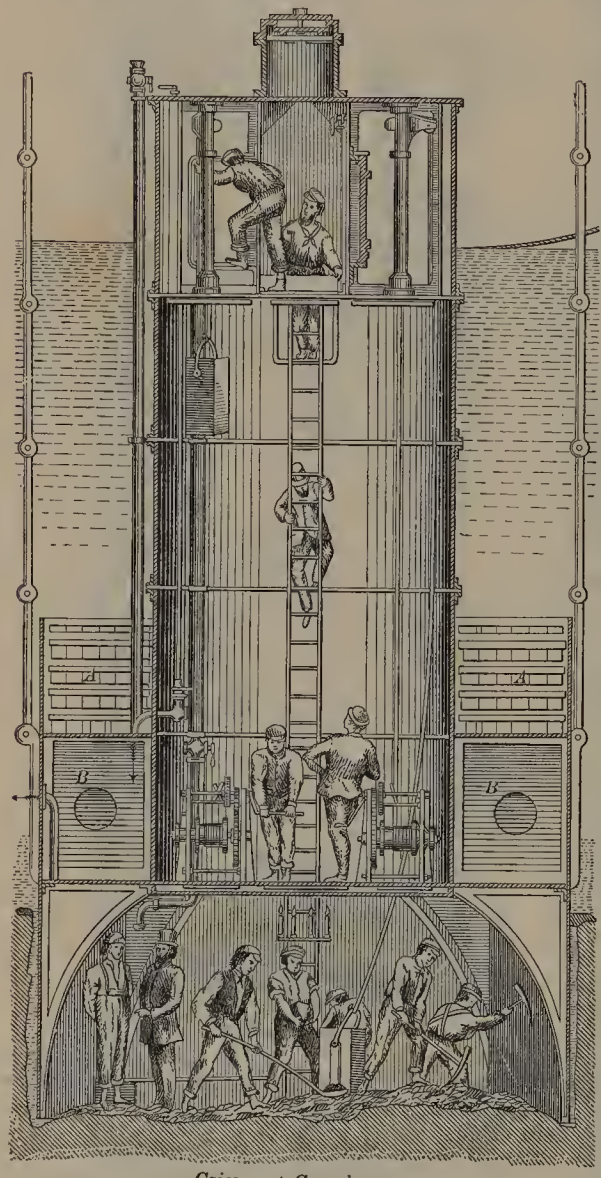
of fourteen cast-iron cylinders placed in a double row, and sunk through the bed of the river into the hard chalk.

This plan is the reverse of Pott's mode of sinking cylinders, in which the air is withdrawn from the interior so as to utilise the pressure of the atmosphere in forcing the pile downward, while the material, of a somewhat soft nature, ascended into the cylinder. The contents were from time to time scooped out, and the air-exhausting process repeated. This plan was adopted with a bridge which crosses the Thames near Richmond, England.

Fig. 1022 is a section of the movable iron caisson used in building the piers of a bridge at Copenhagen, Denmark. It comprises an upper chamber communicating with the air, an intermediate or air-chamber, both equal and cylindrical in section, and a

lower working-chamber of larger section than the foregoing, and adapted to the shape of the pier; the whole raised or lowered by suspension-chains, and ballasted with iron and water contained in two annular chambers *A* and *B*, surrounding the lower part of the air-lock. In working, the apparatus was lowered to the bottom of the water, and an excavation made until a stratum capable of forming a solid foundation was reached; upon this a layer of concrete was laid, and then the structure completed with brick-work faced with granite; the caisson was gradually raised as this progressed, and when it was finished up to the water-line, the caisson with its

Fig. 1022.



Caisson at Copenhagen.

suspending stage and tackling was removed to the site designed for another pier, where a similar operation was repeated.

Caissons of this kind, having an open bottom and provided with air-locks, act upon the principle of the diving-bell, the pressure of air in the working-chamber and air-locks being equal to that of the depth of water in which they are submerged. This renders the use of the air-lock necessary.

The piers of the Illinois and St. Louis Railway-bridge, across the Mississippi, at St. Louis, are constructed by means of an analogous device. See AIR-LOCK, opp. p. 49.

These, however, are not designed to be removable. The matter to be excavated, being principally sand, is brought up by sand-pumps with extension suction-pipes. A hose, connected with a force-pump, is employed to reduce this matter to a proper consistency. When solid rock is reached, the air-chamber, locks, and shafts are filled with concrete to the top of the pier, which has been gradually built up on the roof of the air-chamber, and around the caisson, as the sinking of the latter proceeded.

The caisson designed to find a stable surface and establish the foundation of the pier for the East River Bridge, between New York and Brooklyn, is rectangular; in length, 168 feet; width, 102 feet; interior hight, 9½ feet, with a roof 5 feet thick; the sides are 9 feet thick at the roof, sloping down to a round edge, so as to facilitate its entry into the ground. This part is of cast-iron, protected by boiler-plate; the remainder, of heavy timbers strongly bolted, braced, and specially coated to prevent leakage of air or water through the pores and joints. It is provided with air-shafts and locks, and air-supply shafts for the chambers, and also two water-chambers, into which materials excavated by the workmen are placed, and elevated by a peculiar dredge.

4. A sunk panel in a ceiling. See COFFER.

5. A chest filled with explosive material, laid in or beneath the track or expected position of an enemy.

Cake-cut'ter. A device for cutting sheets of dough into round or ornamental forms, as heart-shaped, etc.

Cake-mix'er. A device for incorporating together the ingredients of cake, etc. It consists of an exterior case containing upright stationary fingers, between which a set of downwardly projecting fingers are caused to rotate by means of an attached crank, the dough or batter being stirred between the two.

Cal'a-bas. An early light form of musket. Used in and after 1578.

Cal'a-man'co. (*Fabric.*) A woolen stuff, checkered in the warp, so that the checks are seen on one side only. It was fashionable in the time of Addison and his compeers. The stuff had a fine gloss, and was used for ecclesiastical habits. The original goods of that name was made of camel's-hair, as the name indicates.

Cal'a-mine. A native carbonate of zinc. The original means of alloying copper with zinc, obtaining brass. This beautiful alloy was known long before the true theory of its production was understood. Calamine was known to the Greeks, Romans, and Arabians, but does not seem to have been considered as a metallic ore. It was ascertained empirically that fusing copper in contact with a certain stone gave it a yellow color, and the result — brass — was highly valued. Aristotle and Strabo refer to this earth, as do also Ambrosius, Bishop of Milan, fourth century; Primasius, Bishop of Adrumetum, in Africa, sixth century; and Isidore, Bishop of Seville, seventh century. These learned prelates mention an addition by which copper acquired a gold color. This was undoubtedly *calamine*.

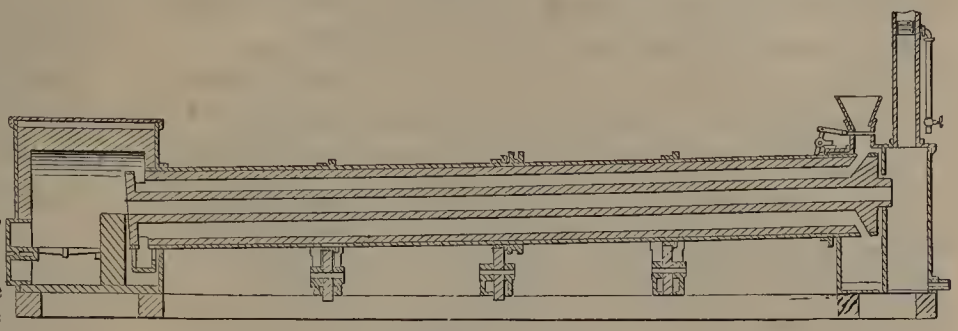
Albertus Magnus, A. D. 1280, seems to have suspected the truth; but it was reserved for Paracelsus, who died in 1541, to define zinc as a metal and give it the proper standing in its group. The great Paracelsus was an empiric rather than a philosopher, but experiment has evolved the facts around which theories are spun.

Ca-lash'. (*Vehicle.*) A light carriage with very low wheels. It may be open, or covered with a folding top, which may be let down at pleasure.

Ca-lash'-top. (*Vehicle.*) A folding leather top, with bows and joints; sometimes called a *half-head.*

Cal'car. 1. (*Glass-making.*) A furnace in which glass *frit* is calcined, to effect a partial union before it is vitrified in the glass *pot*. The word is derived from the French *calquaise*. *Colcar*. See FRITTING-FURNACE.

Fig. 1024.



Rotary Calcining-Furnace.

2. (*Metal.*) An annealing arch or oven.

Cal'ci-na'tion. Oxidation by the application of heat and access of air.

Marble, limestone, and chalk, carbonates of lime, are deprived of their carbonic acid and water by *calcination.*

Gypsum, alum, borax, magnesia, are deprived of their water of crystallization by *calcination.*

Copper and other ores are calcined, to drive off the sulphur, the sulphurets being oxidized and sulphuric acid being disengaged and volatilized.

The *roasting* of ores is a common and analogous process. See ROASTING; DESULPHURIZING.

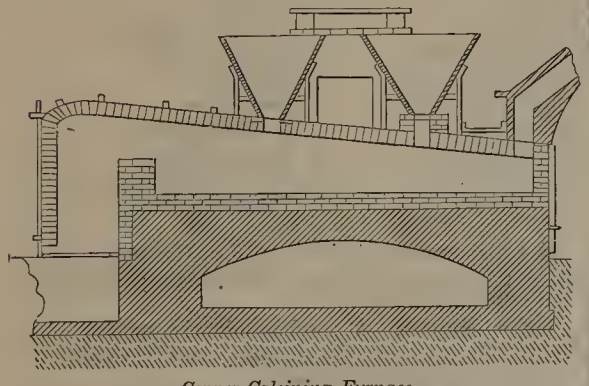
This exposure of a body to a strong heat destroys cohesion of the parts, and renders the body capable of being pulverized. In this condition metallic bodies become *calxes;* otherwise known as metallic oxides.

Cal'ci-na'tion-pot. A sort of crucible used for preparing animal charcoal.

Cal-ci'ner. The calcining or roasting furnace.

Cal-cin'ing-fur'nace. A large reverberatory furnace, having a fire at one end, two chimneys at opposite corners, four doors at which the operation is observed, the *rabbles* introduced, and the material withdrawn, and hoppers above by which the ore is introduced. The charge of copper ore, for instance, is about 3½ tons, which is dropped on to the hearth when the sliding bottoms of the hoppers are withdrawn. The hearth is 23 feet long and 23 feet wide, the vaulted ceiling descending towards the flues. The fire is built upon scoriæ, which are piled upon the grate-bars.

Fig. 1023.



Copper-Calcining Furnace.

The effect of the roasting is to reduce the sulphurets, the sulphur uniting with oxygen and passing off in a gaseous condition. Arsenic, if present, is also sublimed and carried off. The product is in a condition for smelting.

The process with this charge of copper ore takes 11½ hours, and the calcined ores are raked out into reservoirs below the door-ways.

In another example, the cylinder is supported on rollers, and is lined with fire-brick. It is also provided with passages to contain the ore to be calcined, and to conduct the products of combustion from the furnace. The passages are grooved from end to end, and the ore is supplied to the same by means of a hopper, the supply being regulated by the feed-device; the ore escapes through into the trough, from which it is washed by a stream of water.

Other forms of calcining-furnaces are circular, horizontally-rotating tables. See REDUCING; DESULPHURIZING.

Cal'ci-um. Equivalent, 20; symbol, *Ca.*; specific gravity, 1.578; melts at 442° F. It is a light-yellow metal. The carbonate of lime occurs in nature in the forms of limestone, chalk, and marble. The oxide of calcium (lime) is an ingredient in all mortars and cements, and enters into the composition of glass and pottery.

The sulphate of lime (gypsum) occurs naturally in the form of alabaster and selenite. When ground, it forms the well-known plaster-of-paris, used for molding, statuary, and for manure.

The chloride of lime is well known as a bleaching and disinfecting agent.

Cal'ci-um-light. The Drummond or oxyhydrogen light, in which streams of oxygen and hydrogen are directed and inflamed upon a ball of lime whose incandescence gives a very vivid and brilliant light. See DRUMMOND-LIGHT.

Cal'cu-la'ting-ma-chine'. The abacus is the simplest form of calculating-machine. See ABACUS.

A number of these are considered under ARITHOMETER (which see).

Pascal, when 19 years of age (1650), invented one which forms the basis of most of the calculating-machines and registers of the present day. It consists of a train of wheels numbered 0 to 9, and gearing into each other so as respectively to represent units, tens, hundreds, etc. It is the usual registering-device of gas-meters, etc.

Babbage commenced one at the expense of the English government, in 1821, and worked upon it till 1833, when work upon it was suspended, after an outlay of £15,000. The portion completed is in the library of the King's College, London.

This renowned but unfinished machine works upon a peculiar arithmetical principle. The differences between numbers in a table are the elements out of which Mr. Babbage constructs the table itself, and on this account he called his a *Difference-Engine.* For instance, in a table of square numbers, 1, 4, 9, 16, 25, 36, etc., the difference between the first and second is 3; between the second and third, 5; and so we get a series, 3, 5, 7, 9, 11, etc. Again, this

series of first differences, if viewed in a similar manner, presents us with another and remarkable series, 2, 2, 2, etc. It is found that almost all numerical tables, when thus analysed into successive orders of differences, end at last in a very simple series, constituting the materials — the atomic elements, so to speak — which, by addition, will produce all the numbers required in the table. The process of addition lies at the root of the whole method.

How to accomplish this by mechanism was the question which Mr. Babbage undertook to solve. The first term of the table and the first term of each order of differences being given, the whole table can be constructed from those elements; and dials were made to indicate these numbers. There are rows of dials to represent the successive orders of differences, and rows to represent the successive digits in a number; and by an extraordinary assemblage of mechanism, the wheels to which these dials are attached act upon each other in an order, determined by the original adjustment. Each dial has on its edges the set of digits from 0 to 9. There are axes upon which the dials revolve; teeth to the wheels behind the dials; bolts which act on or into these teeth; wedges to withdraw the bolts; and shoulders which regulate the action of the bolts on the teeth-wheels: all this determines the process of addition.

When it is understood that the skillful Dr. Lardner occupied twenty-five pages in the Edinburgh Review in partially describing the complex action of the machine, and gave up other features as hopeless without a mass of illustrative diagrams, we shall be pardoned for not occupying space by attempting farther description.

Harper's Magazine, Vol. XXX. pp. 34–39, gives some account of it, accompanied by a cut.

G. and E. Scheutz, Swedish engineers, constructed a working machine, 1837–43, after studying the Babbage machine; it was brought to England in 1854. It is stated to have been bought for £1000 for the Dudley Observatory, Albany, N. Y.

The Messrs. Scheutz have since completed one for the British government, which was subsequently employed in calculating a large volume of life-tables, which the authorities at Somerset House declare never would have been undertaken had not this machine been in existence.

Cal'cu-la'ting and Meas'ur-ing In'stru-ments. See under the following heads: —

Abacus.
Adding-machine.
Addressing-machine.
Almucanter-staff.
Ambulator.
Angular instruments.
Arrow.
Atwood's machine.
Authometer.
Back-staff.
Balance.
Ballot-box.
Batter-level.
Bench-marks.
Bevel-square.
Boning.
Bow.
Burette.
Calculating-machine.
Caliper-rule.
Calipers.
Chain-inclinometer.
Circumferentor.
Circumventor.
Coin-assorter.
Coin-weighing machine.
Comparateur.
Conformator.
Counter.
Counter-scales.
Cross.
Cross-staff.
Danish balance.
Datum-line.
Declinator.
Delineator.
Demi-circle.
Dendrometer.
Dividers.
Dividing-engine.
Dotchin.
Dumpy-level.
Dynamometer.
Electrometer.
Electric-balance.
Fare-box.
Fare-register.
Faucet. Measuring
Fore-staff.
Funnel. Measuring
Gage.
Gaging-rod.
Garment-measurer.
Gas-meter.
Gas-register.
Geometric square.
Grading-instrument.
Graduated glass.
Grain-measurer.
Grain-scales.
Grain-tester.
Gun-pendulum.
Gunter's chain.
Gunter's scale.
Hydrostatic balance.
Hygrometric balance.
Indicator.
Jacob's staff.
Label.
Letter-balance.
Level (varieties, see LEVEL).
Leveling-staff.
Libella.
Limb.
Linen-prover.
Litrameter.
Log.
Lumber-measurer.
Map-measurer.
Meter (varieties, see METER).
Metrograph.
Metronome.
Micrometer.
Miter-square.
Multiplying-machine.
Napier's bones.
Needle-instrument.
Nonius.
Numbering-machine.
Numbering-stamp.
Object-staff.
Octant.
Odometer.
Optical square.
Outkeeper.
Paging-machine.
Pedometer.
Perambulator.
Plane-table.
Planimeter.
Platform-scales.
Plotting-scale.
Plumb.
Prismatic compass.
Quadrant.
Quadrat.
Recipiangle.
Register.
Scale.
Scales.
Sea-way measurer.
Sector.
Semicircle.
Sextant.
Shuffle-scale.
Sliding-scale.
Specific-gravity apparatus.
Speed-indicator.
Sphereometer.
Spring-balance.
Square.
Stadium.
Station-pointer.
Steelyard.
Stereometer.
Surveying-cross.
Surveying-chain.
Surveying-compass.
Surveying-instruments.
Swan-pan.
Tally.
Tangent-scale.
Tape-measure.
Testing-machine.
Theodolite.
Time-table.
Tourists' indicator.
Transit.
Traverse-board.
Triangular-scale.
Tripod. Surveyor's
Tron.
T-square.
Universal square.
Vernier.
Vernier-compass.
Vernier-transit.
Volvette.
Way-wiser.
Weather-glass.
Weigh-bridge.
Weighing-machine.
Weighing-scales.

See also specific indexes under METER; SCOPE; GAGE; GRAPH; LEVEL; INDICATOR; MICROMETER; REGISTER.

Cal'cu-la'tor. A machine, in the nature of an orrery, invented by Ferguson, for exhibiting the motion of the heavenly bodies.

Cal'cu-li In'stru-ments. (*Surgical.*) These comprise instruments for removing stony concretions in the human bladder; for crushing them so as to allow them to pass through the urethra and be discharged by the natural flow of urine; for grasping and withdrawing them, and for making incisions into the bladder. See LITHONTRIPTER; LITHOLABE; LITHOTOMY FORCEPS; LITHOTOMY KNIFE; LITHOTOMY STAFF, etc.

Cal'e-bas'ser-ie. (Fr.) A Belgian method of remelting iron in a sort of cupola furnace.

Ca-leche'. A small hooded carriage on two wheels.

Cal'en-dar-clock. One which indicates, in ad-

dition to the minute and hour of the day, the day of the week and month, — sometimes the year also, with the phases of the moon, etc.

The Roman calendar is said to have been introduced by Romulus, 738 B. C., who divided the year into ten months, comprising 304 days; fifty days less than the lunar year, and 61 days less than the solar year. Its commencement, therefore, did not correspond with any fixed season. Numa Pompilius, they tell us, 713 B. C., corrected it by adding two months, and made it commence at the winter solstice. Julius Cæsar, 46 B. C., sent for Sosigenes of Alexandria, who again corrected it, making the year 365 days, 6 hours, every fourth year being leap-year. This is denominated the Julian style, and prevailed generally throughout the Roman world. Julius made the first day of the reformed year begin with the day of the new moon following the solstice, which day thus became the first of January.

The year of the change was called the year of confusion, owing to its containing 445 days. The Greeks left off their lunar months, and their intercalations of 45 days every fourth year; the Egyptians changed their *thot*, or first day of their year, which changed from one season to another; and the Hebrews did the like. It was generally adopted for a time in those portions of the three continents dominated by the Romans.

Time works changes, but changes in the modes of measuring time are resented innovations. The vernal and autumnal equinoxes, the summer and winter solstices, each formed the commencement periods for the years over large areas of country at various times. The uniformity of the Roman system was lost when they abandoned their provinces, but as the intellectual center still remained in the South the nations again gave in their adherence. By an edict of Charles IX. in 1564, the beginning of the year was ordered in France, at January the first. The change was not made in England till a much later period, and is far from invariable even now in that country.

In the time of Pope Gregory XIII., A. D. 1582, the calendar had become defective to the amount of ten entire days, the vernal equinox falling on the 11th instead of the 21st of March. This was owing to the fact that the solar year is 365 days, 5 hours, and 49 minutes nearly, instead of 365 days, 6 hours, as defined by the Julian system. To compensate for the error, Gregory ordained, by a brief issued October 5, that the current year (1582) should have only 355 days; October 5 became October 15. To obviate further irregularities, it was determined that a year beginning a century should not be bissextile, with the exception of that beginning each fourth century. Thus the years 1700 and 1800 were not bissextile, nor will 1900 be, but the year 2,000 will be a leap-year. In this manner three days are retrenched in 400 years, because the lapse of 11 minutes 10.3 seconds makes three days in about that period.

The Protestant States of Germany adopted the New Style at various times from 1700 to 1774. Great Britain adopted the New Style by act of Parliament, September, 1752; the 3d of the month being called the 14th. In one of Hogarth's pictures, "The Election," a drunken bummer holds erect a placard with the inscription, "Give us our Eleven Days." He is sitting all in a heap upon the ground, protesting against the loss of time while squandering the present. In some of the English mining-districts, the year is yet divided into 13 "mining months." Contracts are thus made, and wages paid; it has the advantage of causing the month and the week to terminate on the same day.

The Greek Church have not adopted the Gregorian innovation, as they consider it, and still use what we call O. S. (old style). The Jews have their own new year; so have the Turks; the Chinese celebrate their new year by making a dreadful din.

The Russians yet adhere to the Julian style, so that in writing to Russia it is necessary to date thus, for instance, $\frac{12}{24}$ March, or $\frac{25 \text{ September}}{7 \text{ October}}$, or $\frac{28 \text{ December, } 1872}{9 \text{ January, } 1873}$, as the case may be.

The English civil year, from the 14th century till the adoption of the New Style of Gregory XIII. in 1752, commenced on Lady-day, the day of the Annunciation of the B. V. M., March 25; the half-year was at Michaelmas, the Feast of St. Michael, September 29. Leases are yet drawn in England, occupation and rent being calculated with reference to these recurring festivals. The Old Style is still retained in the English Treasury, so that the Christmas dividends are not considered due till Twelfth-day, the midsummer till July 5, and so on. The usage of the commencement of the year at March 25 is still retained, so the first day of the financial year is Lady-day of the Old Style, that is, new Lady-day March 25, + the 11 days removed by act of Parliament 1752, = April 6; thus embodying both the ancient practices, namely, the commencement of the year at about the vernal equinox and the old Julian style, which had lost 11 days in 1798 years.

The Mexicans had a year of 360 days and 5 supplementary days. They divided it into 18 months of 20 days each, and had a leap-year. Their year commenced at the vernal equinox.

The Peruvian year began with the winter solstice.

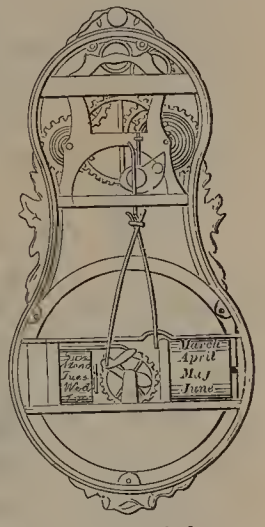
The Jewish civil year is 12 lunar months = 355 days. Their ecclesiastical year begins at the vernal equinox, about March 22. The civil year 5634 A. M. begins September 23, 1873, and ends September 11, 1874.

The Mohammedan year is 12 lunar months = 355 days; the year 1290 A. H. (Anno Hegiræ) commencing March 1, 1873, and ending February 17, 1874.

The Chinese new year commences at midnight on the recurrence of the new moon which falls nearest to the point when the sun is in the 15° of Aquarius; say, the nearest new moon to the 5th of February.

The first day of the new year of the French revolutionary period was September 22, 1792; their year consisted of 12 months of 30 days each, with five sacred (!) days at the end, dedicated to Virtue, Genius, Labor, Opinion, and Reward (!!). The bissextile day each fourth year was devoted to the renewal of the oath of liberty.

Fig. 1025.



Calendar-Clock.

The appearance of the calendar-clock is familiar, the names of the days and months appearing at slits in the dial or case; or else indicated by pointers on a number or lettered dial or dials. The illustration shows one of the first-mentioned kind, in which the names of the days of the week and months of the year are inscribed on two revolving drums, and presented consecutively at slits in the front of the case, — removed, in the example, to expose the works.

Cal'en-der'ing. The series of operations, differing according to the goods, of straightening, damping, pressing, stretching, starching, drying, embossing, and watering woven goods; including the various processes intervening between the bleaching or dyeing and the packing for market.

The fabric is first passed over a water-cistern, kept constantly full, by which it is wetted, preparatory to being drawn through a pair of rollers, by which it is partially smoothed. It is also pulled out breadthwise, and the edges knocked against a smooth beating-stock.

It is now ready to go through the *mangle*, which consists of a number of rollers, adjustable to any desired pressure, so as to remove any creases which may remain. For this purpose, the bottom rollers are sometimes grooved, the grooves spreading outwardly from the center on either side. Above these are three smooth rollers, two of wood and one of brass, which equalize the surface and stretch the cloth.

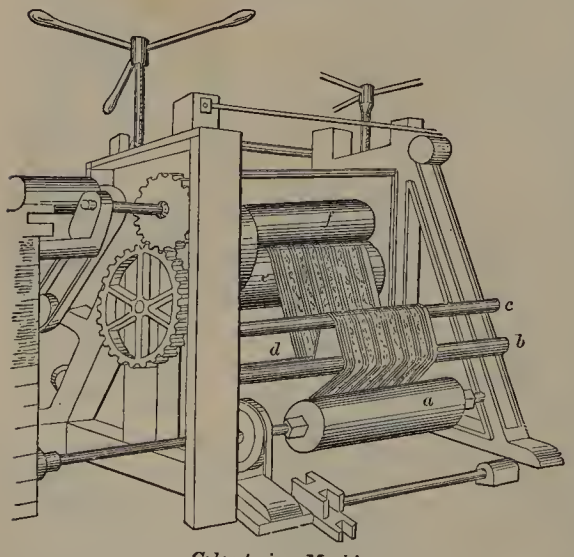
The starching is effected by drawing the cloth under a roller, which dips into a trough of flour-starch, fermented, previous to boiling, to deprive it of gluten. Superfluous starch is removed by other rollers, between which the cloth passes, and falls back into the trough.

The stuff is now dried, by passing it over heated cylinders of tinned iron or copper in the case of heavy goods, while muslins are merely stretched on frames in a warm room. What is called *patent finish* may be given it by working the two long sides of the frame backwards and forwards in opposite directions, giving the muslin a diagonal motion, which is continued until it is quite dry. This removes the harsh and stiff appearance caused by the starch.

The process of giving the glossy surface-finish distinctively known as calendering is described under CALENDERING-MACHINE.

Cal'en-der'ing-ma-chine'. Though the business of the calenderer includes all the finishing processes by which bleached or dyed cotton and linen goods are stretched, starched, glossed, and pressed, yet the *calendering-machine* proper is a machine between whose loaded rollers the cloth is passed to give it the finish and luster desired.

Fig. 1026.



Calendering-Machine.

Cloth which was formerly calendered by burnishing with a smooth flint-stone, is now glazed by passing between rollers, one of which moves slower than the other, so that a rubbing action is obtained.

The machine was introduced into England by the Huguenots about 1685, on the revocation of the Edict of Nantes. This edict was granted to the Protestants of France by Henry IV., April 13, 1598, and revoked by Louis XIV., October 22, 1685. They scattered to England, to Charleston, S. C., and other places, taking their industry and their skill with them.

The fabric is first damped by passing it slowly over the *damping* or *degging machine*, containing a circular brush, the points of which, as they rapidly revolve, just touch the surface of the water and dash a cloud of fine spray against the cloth, by which it is uniformly damped. It is then ready for calendering.

By means of a weighted lever, or by screws on top of the calendering-machine, any required amount of pressure may be applied to the fabric; a very great pressure, by flattening the threads, gives a smooth and silky surface. By passing two folds between the rollers at the same time, the threads of each mutually produce a meshed appearance on the other. A watered surface is produced by passing the goods in a very damp state through plain or indented rollers; sometimes a slight lateral motion is given it.

The rollers are heated, when required, by inserting a red-hot cylinder into them.

Cal'i-ber. 1. The bore of a fire-arm or gun, or the weight of the ball which fills it to its capacity, allowing for *windage*.

Sometimes applied to steam cylinders and pumps.

It finds three different modes of expression:—

a. The diameter in inches; as, 8-inch gun, 10-inch cylinder, etc.

b. In the weight of the solid, round shot adapted thereto; as, 8-pounder, 12-pounder gun.

c. In the hundredths of an inch expressed decimally; as, carbines and rifles of .44, .50, .55 inch caliber.

2. (*Horology.*) *a.* The plate on which the arrangement of the pieces of a clock is traced. The pattern-plate.

b. The space between two plates of a watch, which determines the flatness of the movement.

Cal'i-ber-com'pass. A form of calipers adapted to measure the sizes of bores. See CALIPERS.

Another kind is used for measuring shot and shell. See SHELL-GAGE.

Cal'i-ber-rule. A gunner's calipers; having two scales to determine the weight of a ball from its diameter, and conversely.

Cal'i-co-print'ing. A mode of impressing figured designs upon cloth; the term also including modes and processes not strictly mechanical.

Calico is printed cotton cloth. In England, such are called *prints; calico* being the plain white cotton cloth, bleached or unbleached.

The name *calico* is derived from Calicut, a seaport of Malabar, visited by Vasco de Gama in 1498, and afterwards the principal seat of the Portuguese power in India. Calico was brought from India to England in 1631.

Where the art originated, it cannot be said to be useless to inquire; for, though the positive answer may not appear, the inquiry leads in directions which will be either "fresh fields and pastures new," or to regions which we tread again with pleasure and enthusiasm.

The Chinese have used printing-blocks from time immemorial. Printing on cloth preceded printing on paper, but it cannot now be determined how long ago. The Chinese applied the art to printing on bark, leaves, skins, or scale-board.

The natives of India were far in advance of all other people, both in the variety of their styles and the excellence of their execution. They used wax as a *resist;* used *mordants* of different kinds, so as to produce different colors by boiling the cloth in a solution of one color. They also had the *bandanna* style, in which spots are left white by topical pressure on the parts, preventing the access of the dye.

Of the *resist* style, the *pallampoor* may be cited. In this, the pattern was painted in wax upon the cloth, which was then dyed. (See PALLAMPOOR.) Of the *mordant* style we have an excellent account in Pliny (d. A. D. 79) : —

"Robes and white veils are painted in Egypt in a wonderful way; they are first imbrued, not with dyes, but with dye-absorbing drugs, by which, though they seem to be unaltered, yet, when immersed for a little while in a caldron of the boiling dye-liquor, they are found to become painted. Yet, as there is only one color in the caldron, it is marvellous to see many colors imparted to the robe, in consequence of the influence of the excipient drug. Nor can the dye be washed out. A caldron, which would of itself merely confuse the colors of cloths previously dyed, is thus made to impart several colors from a single dye-stuff, *painting as it boils.*" See MORDANT.

It will be noticed that Pliny credits the Egyptians with the work; this may be true as to the goods he saw, but it is also quite likely that the goods he saw were of Hindoostanee manufacture, brought to the Mediterranean by the Arabians. It is evident that the Egyptians also practiced the art, but it was upon linen, and not cotton, the peculiar stuff which Herodotus calls *tree-wool* and rightly ascribes to India. (See COTTON.) In the latter country, the calico-printing, whether of the *resist* or *mordant* styles, was performed by hand, and was rather *painting* than *printing*, as to the mode of its execution.

Variegated linen cloths of Sidon are mentioned by Homer; and Herodotus speaks of the garments of the inhabitants of the Caucasus as variegated with figures dyed by infusions of leaves.

Cortez found the Mexicans in possession of the art, their garments of cotton being adorned with Dolly Varden figures in black, blue, red, yellow, and green.

The art was practiced in Asia Minor and the Levant long before its introduction into Europe, and even then it came in at the southwest, with the Saracens. Abderahman III. founded the cotton, silk, and leather manufactures in Spain, about A. D. 930. He also devoted great attention to the sugar-cane, rice, and the mulberry. This great Arabian people also taught Europe to make Chinese paper of pulped fiber.

It seems a pity that these gentlemen should be worsted by those gloomy tyrants, the Pedros and Philips, and that the liberality and civilization of Cordova should be superseded by the bigotry of Dominic.

About the close of the seventeenth century, Augsburg became famous for the manufacture of its printed cottons and linens. About the same time, that is, in 1696, calico-printing was introduced into England from France, by one of the French victims of the revolution of the Edict of Nantes. He established works on the Thames, near Richmond. This villainous act of Louis XIV. inured to the benefit of other nations, especially England, who gave an asylum to many industrious artificers and artists. About twenty-five years afterwards, the linen, silk, and woolen manufacturers obtained a law against the use of printed cotton goods, either imported or home-made. This was relaxed in 1730 to this extent, that goods with linen chain and cotton filling were allowed to be printed, paying an excise duty equal to twelve cents per square yard. In 1774 this restriction was removed, all cotton printed goods were allowed to be made; the duty was reduced to six cents per square yard. This was afterwards increased to seven cents, and in 1831 was abolished.

The history of the fight in France of printed calicoes against the linen and woolen manufacturers is substantially similar to that just recorded, except that the government of France resisted the mobs instead of becoming subservient to them, as in England. Thus the French passed through the ordeal of absurd sumptuary legislation, and got rid of the incubus sooner than their more conservative neighbors north of "the Channel."

"Sir Martin Noell told us the dispute between him, as farmer of the additional duty, and the East India Company, whether callico be linnen or no; which he says it is, having been ever esteemed so: they say it is made of cotton woole, and grows upon trees, not like flax and hemp. But it was carried against the Company, though they stand out against the verdict." — *Pepys's Diary*, February 27, 1664.

Coloring substances for calico-printing are divided into *substantive* and *adjective*. The former are capable of producing permanent dyes of themselves; the latter require certain intermediate matters, called *mordants*.

The commonest mordants are the acetate of iron, the acetate of alumina, and some solutions of tin.

1. *Madder* or *chintz style.*

The parts of the cloth which are to have a madder color imparted to them are printed with a mordant. After *ageing*, that is, allowing the mordant to become firmly attached to the cloth, the superfluous mordant is washed away by a warm mixture of cow-dung and water. It is then washed and *winced* in a weak solution of alum and size. It is then drawn through a colored solution, and this becomes fixed in the parts where the mordant has been applied. The cloth is washed in soap and water, bran and water, or dilute solution of chloride of lime, which removes the dye from the unmordanted portion of the cloth. It is then ready for rinsing, drying, starching, calendering, and folding.

2. *Printing by steam.*

In this process the colors printed with a mordant are fixed by steam driven through the cloth and acting upon the mordant. After drying and ageing, the thickening material is washed out, and the cloth finished in the usual manner by starching and calendering.

3. *The padding* or *plaquage style.*

By this a pattern may be produced on white or colored ground, or a ground may be formed for a design in other colors. The cloth is spread with a colored paste, dried, and then printed with another colored solution; a chemical reaction takes place where the colors are mingled, forming a pattern upon the general ground of the former color. This is the style referred to by Pliny, — "a design on a white ground is produced by printing with one solution and wincing in the other."

4. The *resist* or *reserve style.*

The white cloth is printed with a paste which resists the action of color when the cloth is placed in the vat. The cloth is then dyed in the piece, and subsequent washing removes the dye from the part protected by the *resist-paste.*

5. The *discharge* or *rongeant style.*

The dyed or mordanted cloth is printed with a discharger, which renders the color, where it is im-

pressed, colorless or soluble, so that it may be washed out.

6. The *china-blue style.*

This is only practiced with indigo, of which several shades may be associated with white. The bleached calico is printed with a combination of indigo and other materials, aged, and immersed successively in three solutions. The effect is to cause the surface-indigo to permeate the cloth and become precipitated in an insoluble form.

7. *Decoloring* or *enlevage style.*

The dyed goods are treated with chlorine or chromic acid to discharge the colors at the required places.

8. *Spirit-color printing.*

The colors are produced by a mixture of dye extracts and solution of tin, called by the dyers *spirits of tin.*

9. The *bandanna* style, in which spots are left white by topical pressure on the parts, preventing the access of the dye.

There are several mechanical modes of printing calico: —

a. Wooden blocks prepared with a pattern on one surface and pressed down on the cloth by hand.

b. Several such blocks fixed in a frame and worked by machinery.

c. The pattern engraved on a flat copper plate, which is pressed down upon the cloth.

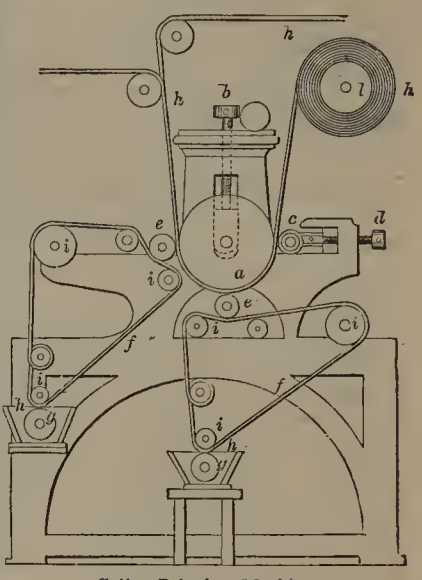
d. The pattern is engraved on a copper cylinder, over the surface of which the cloth is made to travel. By a combination of cylinders, various colors are laid on to form a various-colored print.

All the cheaper printed cottons are now printed by the cylinder process. The pattern is engraved on a roller of soft steel, about three inches long and one in diameter, called the *die*, so as to exactly occupy its external surface; this is hardened by being heated to redness and suddenly plunged in cold water. The design is then transferred by means of a rotatory press from the *die* to a similar small roller in a soft state, called the *mill*, producing an impression in relief. The *mill* is then hardened and placed in a rotary press, imprinting the pattern on the copper *cylinder* from 30 to 40 inches long and from 4 to 12 inches wide, from which the calico is printed; the impression has to be repeated a sufficient number of times to cover the face of the copper cylinder, care being taken to make the junctions of the small cylinder accurately fit each other.

For costly and delicate goods, such as shawls and velvets, the block method of printing is still adhered to. In this method, each color has a block to itself, on which a certain portion of the pattern is cut or engraved; the blocks are used singly and by hand, each printing as much as its size will permit. Where the whole design is but a repetition of one small pattern, the whole surface of the cloth is printed by a succession of applications of the same two or three blocks; but where a large shawl, for example, displays a design which is not merely a repetition of small bits of pattern, the number of blocks often becomes multiplied to an extraordinary degree. A fine barege shawl is mentioned as having required more than five hundred blocks to produce the entire pattern, every one representing a different part of the device, either in color or pattern, from any of the others. The great number of the blocks in such a case is principally due to the fineness, intricacy, and the non-repetitive character of the pattern, and not to its size, unlike the *loud* trousers pattern of Regent Street, which required that three gentlemen should walk abreast to exhibit it.

In the calico-printing machine, the pattern is engraved on cylinders of copper, which supply themselves with their respective colors during their revolutions, by means of inking-aprons *f* from the color-tubs *h*. Each cylinder is engraved with its portion of the pattern in relief, and they are so arranged that each makes its impression in the exact spot in relation to the other parts of the pattern.

Fig. 1027.



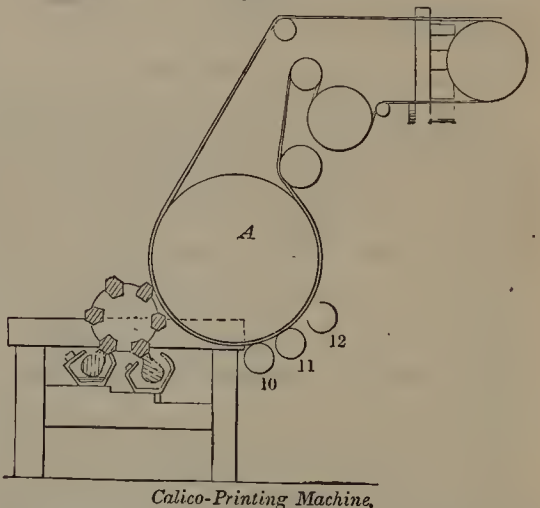
Calico-Printing Machine.

The machine illustrated is adapted for two pattern-rollers. The cloth to be printed is unwound from a roller *l*, and passes beneath the smooth roller *a*, receiving an impression from each of the rollers *e* as it passes. The roller *a* runs in journal boxes, which are regulated by a set screw *b* at each end, and a smoothing-roller *c*, actuated by a set screw *d*, holds the cloth against the roller *a*. The pattern-rollers *e e* are inked by the aprons *f f*, which pass over the rollers *i i i*, the outside surfaces of the aprons coming in contact with the surfaces of the rollers *g g*, which revolve in the ink-troughs *h h*.

After receiving the impressions from the pattern-rollers *e e*, the cloth *h* is led off to be dried and folded.

In another form of the machine, each copper cylinder is engraved with as much of the pattern as

Fig. 1028.



Calico-Printing Machine.

the printing in a particular color; the pattern being sunken in, not raised upon, the cylinder. The cylinders are arranged horizontally, and each, as it rotates, dips into a trough containing its own particular color, mixed as a thickish liquid. A long knife, called a *doctor*, then comes in contact with the surface, and scrapes off all the color, except that contained in the engraved lines of the pattern. The

cloth is made to travel over rollers and beams, and to come in contact with the printing-cylinders in succession, being pressed upon each in its passage, and receiving from each an impression. The cylinders are exactly placed in reference to the pattern, and the tension and rate of the cloth is so regulated that it comes to each cylinder in exact time and place to receive each color in proper relation to each other.

Fig. 1028 shows a form of machine in which the cloth is presented serially to a set of hexagonal prisms whose facets, at each rotation of the prism-carrier, receive their color from cams which rotate in their respective color-troughs. Two of these troughs are shown, but more may be applied if desired. The motion of the prism-reel and of the color-cams is so prearranged that the salient portion of each cam advances to give color to its appropriate prism, while the others pass by uncolored. 10, 11, 12, are ordinary printing-rolls, which may be auxiliary to the prismatic colorers. *A* is the main cylinder which carries the end apron on which the cloth passes from the pay-off roller, past the printing, and thence to the dryer or ageing-loft.

Cal'i-duct. A pipe for conveying hot water or steam for heating purposes.

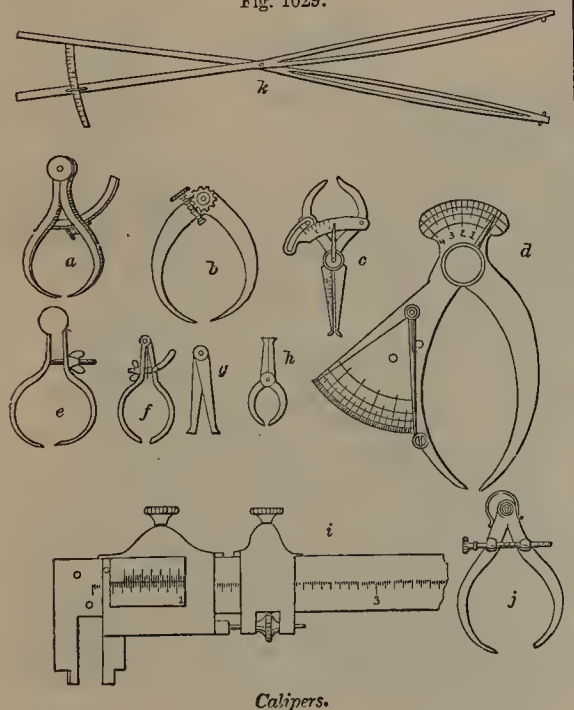
A term given by Cardinal Polignac, 1713, to the pipes, etc., in which air was heated by the adjacent fire, and from which the air passed into the room.

They were used by the ancient Romans (see HYPOCAUST), and in the Arab palaces of Cordova, in Spain, about A. D. 1000, being imbedded in the walls, and carrying the heat of the hypocaust to the apartments in winter.

Ca'lin. An alloy of lead and tin, used by the Chinese as a lining for tea canisters and boxes.

Cal'i-pers. An instrument, jointed like a pair

Fig. 1029.



Calipers.

of dividers, but with arched legs, and adapted for taking the diameter of convex or concave bodies.

It is said to have been invented by an artificer of Nuremberg in 1540. This will not do; the calipers is a mechanical thumb and finger, a device of very ancient date, and is shown on Roman tombs. See COMPASSES.

a is a *bow* calipers, with arc and tangent screw.

b, a calipers whose legs are operated by a worm-wheel and pinion.

c is an *inside and outside* calipers with a graduated arc and index-finger.

d is a calipers which shows by the index and arc at the joint the distension of the points. One leg has a spring, and expands as the calipers is passed over the work, the index on the leg showing the amount of variation from the true size to which the joints have been set.

e is a spring calipers.

f, a common form of calipers with arc.

g, inside calipers. *h*, inside and outside calipers.

i is a vernier calipers, for inside or outside measurements, which reads to thousandths of inches. On the other side are sixty-fourths or fiftieths of inches to read without a vernier. The description of the mode of using this instrument is well worth embodying here, but we cannot spare room.

j is a spring calipers with pivoted operating screw and nut.

k is a calipers for measuring standing or cut timber; it has arms about thirteen feet long, and a brass arc on which are figures denoting the quarter-girth in feet and inches.

Gunners' calipers are for measuring the bore or caliber of guns and projectiles.

A scale like a sliding-rule has different sets of numbers engraved on it, to exhibit the corresponding diameters in inches and weights in pounds.

The graduation is in accordance with the rule that with balls of the same metal the weights of the balls are as the cubes of their diameters.

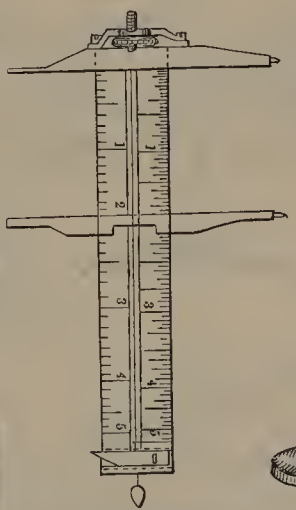
Calipers for inspecting hollow projectiles comprise:—

Those for measuring the thickness of metal at the bottom, at the sides, and at the fuse-hole reinforce.

The first consists of a semicircular arm having a diametrical sliding index; the second, of a similar arm, pivoted, and the third of a graduated bar with a stationary and a sliding toe. See SHELL-GAGE.

Cal'i-per-square. A square having a graduated bar and adjustable jaw or jaws. The example is a rule carrying two cross-heads, one of which is adjusted slightly by a nut, the other being movable along the rule. The cross-heads on one side are adapted to the measurement of interior diameters or sizes, and on the other side to the measurement of external sizes. See also *i*, Fig. 1029.

Fig. 1030.



Caliper-Square.

Fig. 1031.

Calks.

Cal'i-ver. An old form of hand-gun. An *arquebus*.

Calk. A projection from a shoe or clog which digs into the ice or frozen ground to prevent slipping. The word is allied to the Anglo-Saxon word *calc*, a shoe; or the Latin *calcar*, a spur.

In a horseshoe, the calk *a* consists of a downward projection from the heel, made by turning over the iron of the heel and sharpening it.

The calk *b* attached to a boot consists of a plate with spurs, which project a little below the heel.

Calk'ing. 1. (*Shipwrighting.*) The process of filling the seams between the planks of vessels, and of spreading the ends of the *treenails*, by driving in oakum.

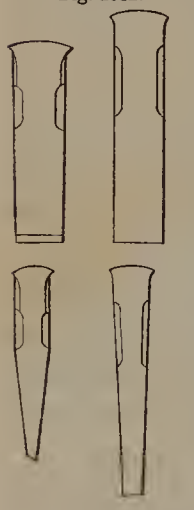
Oakum is made by cutting old ropes and cables into short lengths called *junk*, and picking that to pieces.

The seam is opened by a *reaming-iron*, driven by a *beetle*, and the threads of oakum driven in, one after another, by a *calking-iron* and *beetle*. It is farther compressed by a *making-iron*, or *horse-iron*, held by one man and driven by another. This is called *horsing-up*.

It is then *payed* with melted pitch.

The calking of plates in iron ships is performed by two men, — one holding a chisel or calking-tool, and the other striking it with a hammer, making a slight indentation along the seam. The effect of this is to force the edge of one plate hard against the other, and thus fill up any slight crevice between the plates which the rivets have failed to close. See CALKING-CHISEL.

Fig. 1032.



2. Tracing with a style the outlines of a print which lies on a colored-chalk paper superimposed on a white sheet of paper. By this means a chalk outline is imparted to the lower paper. It is the principle of the manifold writer. Also written *calquing*.

Calk'ing-an'vil. A blacksmith's anvil or hardy, adapted for the turning over, forming, and sharpening of horseshoe-calks.

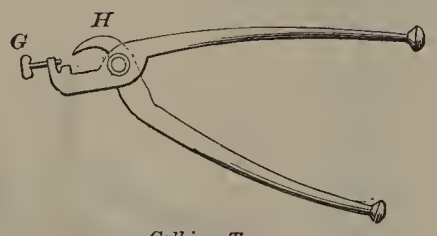
Calk'ing-chis'el. Calking-chisels for closing the seams between iron plates are made of different sizes and forms. The annexed illustration is as good as a specific description. It shows chisels in side and front views, and also the operation.

Calking-Chisels.

Calk'ing-i'ron. A CALKING-CHISEL (which see).

Calk'ing-tongs. An implement for sharpening the calks of horseshoes. In the example, the set screw *G* is set so that the rear of the calk may

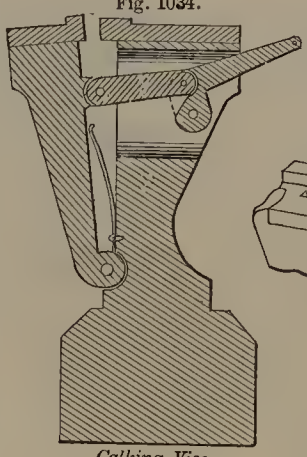
Fig. 1033.



Calking-Tongs.

bear against it, while its lower edge is trimmed by the chisel-edged jaw *H* without detaching the shoe.

Fig. 1034.

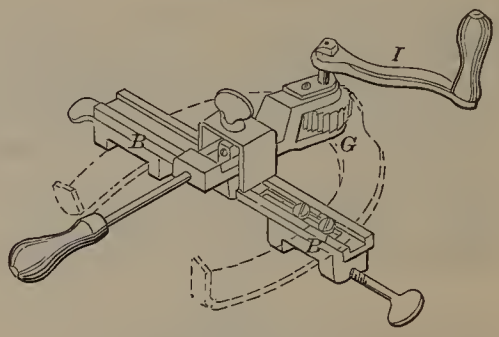


Calking-Vise.

Calk'ing-vise. An anvil with a jaw attached, acting as a vise to grasp the shoe while the calks are swaged by the hammer.

Calk-sharp'en-er. A device for sharpening horseshoe-calks. In the example, the frame *B* is clamped to the shoe by means of a screw. The ro-

Fig 1035.

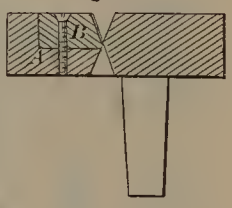


Calk-Sharpener.

tary cutter *G* is adjustable on the frame, and is operated by a crank *I*.

Calk-swage. A swage for forming horseshoe-calks. That illustrated has the die-piece *B* inserted into a metallic block *A*, so that it may be readily removed and replaced by another. The shank sets in the hardy-hole of the anvil.

Fig. 1036.



Calk-Swage.

Call. A boatswain's whistle.

Cal-laud Bat'ter-y. A double-fluid battery, invented by Jean Armand Callaud, a French electrician; practically a modification of Daniell's.

The porous cup or partition is dispensed with, a single cell being used; the separation of the fluids being effected by their difference in specific gravity.

In the cell the copper or — element is at the bottom, while the zinc or + element is suspended in the upper half of the cell, which is then filled with a saturated solution of sulphate of zinc. Sulphate of copper, in crystals, is then gently dropped in, falling to the bottom, where it dissolves, and remains, owing to its greater specific gravity.

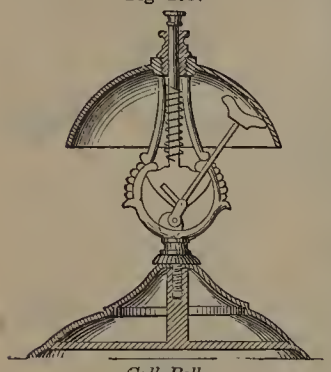
Of the Callaud battery, there are several modifications; namely, —

Hill's, in which a vertical glass-tube, open at both ends, is introduced, its lower end resting in the copper solution, its upper end extending up to the top of the cell. Its function is that of a feeding-reservoir for the copper solution, the sulphate of copper being introduced therein.

Phelps's, in which the changes are merely mechanical, giving greater surface to the elements, and suspending the zinc by a central upright arm from a three-armed support resting on top of the cell.

The Callaud battery has met with great favor, and gone into extended use on account of its simplicity, cheapness, and constancy.

Fig. 1037.



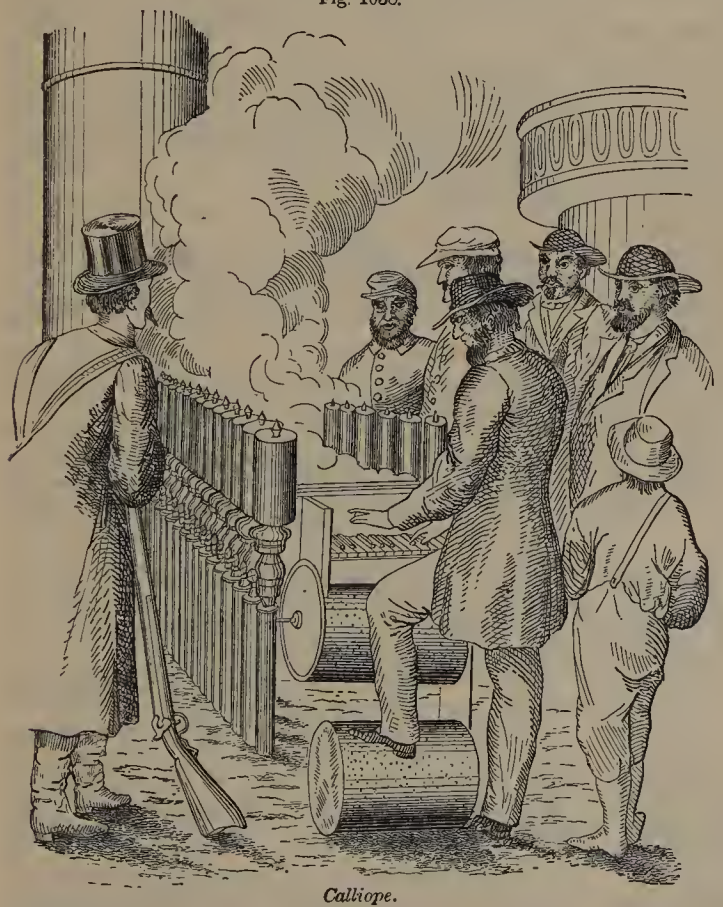
Call-Bell.

Call-bell. A small stationary hand-bell. In that illustrated a vertical plunger passes through the axis of the bell, and, by means of its slotted plate, vibrates the clapper, which is pivoted beneath. The blow is repeated as the plunger is again raised by the spiral spring.

Cal-li'o-pe. Calliope (the sweet-voiced) was, in ancient mythology, the muse who presided over epic poetry, or poetry in general.

The instrument represented in Fig. 1038 can, however, hardly lay claim to be called *sweet*-voiced. It consists of a series of steam-whistles toned to produce musical notes. The valves by which steam is admitted to the whistles are operated by keys arranged like those of an organ.

Fig. 1038.



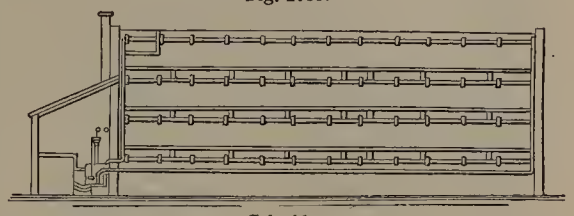
Calliope.

It is sometimes placed on the upper or hurricane deck of steamboats, serving to amuse the passengers and astonish the natives on shore.

Ca-lor'ic-en'gine. A name conferred by Ericsson upon his hot-air engine. See AIR-ENGINE.

Ca-lor'i-fere. A French heating-apparatus, invented by Bonnemain, of Paris, 1777, in which an ascending current of hot water proceeds from a boiler, and, after coursing through the system of heating-pipes in the various stories and apartments, descends again to the boiler, comparatively cool.

Fig. 1039.



Calorifere.

The system has been amplified, hot-water urns being placed in the various apartments and heated by a branch-pipe from the main artery, the cooled water or water of condensation flowing to the venous system of descending pipes, which reach again the heart whence the water flowed.

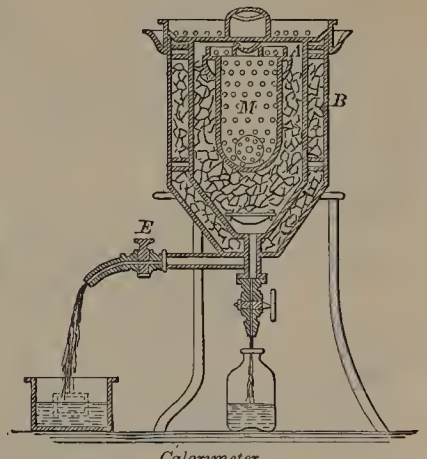
Watt warmed buildings in this manner in 1784.

Cal'o-rif'ics. In the systematic classification of mechanical subjects, those devices concerned in heating, by fire directly or by steam, hot water, or hot air in vessels or by pipes or flues.

Heating and cooking stoves, grates, ranges, and fireplaces; hot-air furnaces, flues, and ducts, their dampers, valves, regulators, and thermostats; gas stoves and cookers; cooking-utensils, and the appliances of the above. See list under STOVES AND HEATING-APPLIANCES.

Cal'o-rim'e-ter. An instrument for measuring the quantity of heat given out by bodies in passing from one temperature to another.

Fig. 1040.



Calorimeter.

In its special form, as invented by Lavoisier and Laplace, it operates by the melting of ice around the body to be tested; determining the specific heat of the body.

This method consists in heating a given weight of the body up to some fixed temperature, say 212°, then plunging it into dry ice, and subsequently determining the amount of ice which it melts in cooling down to 32°.

The body whose specific heat is to be determined, after having been weighed and heated for some time in an oil or water bath, is placed in the central compartment *M*. A lid is quickly placed over it, and covered with pounded ice, which already fills the surrounding vessel *A*. Over this another lid is placed and covered with ice, which the outer concentric vessel *B* also contains. Finally a double lid covers the whole. The vessel *M* is thin, so that the ice in *A* is quickly melted, and, flowing out by the stopcock, is collected and weighed. The ice in *B* is but little affected, and any water that may collect passes off by stopcock *E*.

The latent heat of water being known, the specific heat of the substance may be readily calculated from the quantity of water which has been melted from the ice in *A*.

Black's method was a single block of ice in which a cavity was made to contain the heated body over which an ice cover was laid. After a time the substance and cavity were wiped dry with a cloth, the weight of the water of liquefaction determined, including the moisture imbibed by the cloth.

Other modes are cited by writers on thermotics.

Ca-lor'i-mo'tor. A voltaic battery formed of a single pair of extremely large plates. The plates may be coiled around each other, and suspended over a tub of acidulated water, into which they may be lowered at pleasure.

The apparatus possesses extraordinary deflagrating power.

Ca-lotte'. (*Architecture.*) A cup-shaped elevation or small dome in the ceiling of a chamber or alcove, to increase its elevation; so called from *calotte*, a segment of a sphere.

Cal'o-type. (*Photography.*) A process invented by Fox Talbot. Paper saturated with iodide of silver is exposed to light, and the latent image developed, and afterwards fixed by hyposulphite of soda.

The paper is floated on a solution of iodide of potassium, dried, floated on a solution of nitrate of silver. The effect is a film of iodide of silver, by the double decomposition of the two salts in contact. Excess of salts is washed away, and the paper dried, in the dark. The sheet, before use, is floated on a solution of gallo-nitrate of silver. After exposure in the camera the latent image is developed by nitrate of silver and saturated solution of gallic acid; then fixed by bromide of potassium and hyposulphite of soda. The result is a negative, which by a repetition of the process produces a positive.

Calqu'ing. See CALKING.

Cal'trop. (*Fortification.*) A pointed instrument to impede the progress of cavalry.

Fig. 1041.

Caltrop.

It is a ball with four spikes, so arranged that, fall as it will, one is vertical and the other three stand as a tripod.

Bronze caltrops (*tribulus*) were used by the Romans.

Calx. 1. Broken and refuse glass, which is restored to the pots.

2. A metallic oxide, the result of the calcination of a metallic earth or ore.

Cal'y-on. Flint or pebble stone, used in building walls, etc.

Cam. A revolving disk, usually of a spiral, eccentric, or heart shape, fixed on a shaft; or such other form as to impart to a lever, rod, or block in contact with it such velocity or alternating or variable motion as may be required. See CAM-WHEEL.

The cam for one form of expansion gear of steam-engines has a disk of cast-iron whose periphery is cut in steps so as to suit the different degrees of expansion.

Ca-ma'ieu. (*Fine Arts.*) A painting in a single color. A *monochrome*.

Cam-ball Valve. A valve actuated by a cam on the axis of a ball-lever, so that, as the float rises in the cistern, the cam shall press against the stem of the valve and close it against its seat, thus shutting off the supply when a given level has been attained in the cistern, tank, or boiler.

Fig. 1042.

Cam-Ball Valve.

Cam-bayes'. Cotton cloths made in Bengal, Madras, and other places in India.

Cam'ber. 1. A curvature upwards, as a deck amidships, a bridge, a beam, or a lintel.

It is given for —

a. Conferring stability, as in a bridge, beam, or girder.

b. Giving a water-shed, as in a deck or roof.

c. Compensating for settling or subsidence, as in the soffits of straight arches.

2. The curve of a ship's plank.

Cam'ber-beam. A beam which is laid upon the *straining-beam* in a truncated roof, and supports the lead or copper covering of the summit. It has a slope towards each end to run off the water.

Cam'ber-slip. (*Bricklaying.*) A strip of wood with one edge curved equal to a rise of one inch in six feet. Used for striking the soffit-lines of straight arches, to give them a slight rise, in order that they may settle straight.

Cam'brel. An iron with hooks on which to hang meat. See GAMBREL.

Cam'bric. (*Fabric.*) *a.* A delicate linen fabric, originally manufactured at Cambray.

It is of fine texture, white, and is checked, striped, or plain.

b. A cotton fabric in imitation of fine linen. Its varieties are, glazed, white, and colored for linings; twilled, figured, striped, and corded.

Came. A grooved bar of lead adapted to hold a pane of glass. These cames cross each other at angles, being usually diagonally disposed in lattice form in the frame of the window. The diamond-shaped panes are termed *quarrels;* the mode of glazing, *fret-work*.

Cam'el. 1. A water-tight structure placed beneath a vessel or a load, to raise it in the water, in order to assist its passage over a shoal, a bar, or to enable it to be navigated in shoal-water.

Camels were used by the ancients in floating and moving heavy obelisks and monoliths.

The camels used by the Venetians for floating large vessels over the Laguna consisted of four cases with concave sides, so made as to embrace the whole ship. They were towed under the ship, fastened together, and the water was then pumped out.

Camels are in frequent use in Holland for floating vessels over the sands and bars. The length of one of these camels is 127 feet; the breadth at one end is 22 feet, at the other 13 feet. The interior is divided by water-tight partitions.

A vessel drawing 15 feet of water could, by this means, be made to draw only 11 feet, and the largest man-of-war in the Dutch service could be made to pass the sand-bars of the Zuyder Zee. The in-

vention, in Holland, is ascribed to Meuves Meindertszoon Bakker, of Amsterdam, about 1688.

The approaches to Amsterdam had always been obstructed by sand-bars and similar obstacles, so that vessels of heavy draft were forced to receive and deliver the greater part of their cargoes several miles below the city, which was effected by means of lighters. To enable large vessels to pass the shoals, previous to the invention of the camel, large chests filled with water were fastened to their bottoms, and the water was afterwards pumped out. This method was attended with great difficulty, but in the year 1672 it was employed to get the whole Dutch fleet to sea.

The camel of Bakker consisted of two half-ships built in such a manner that they could be applied below water on each side of the hull of a large vessel.

On the deck of each were a number of windlasses from which ropes proceeded through openings in the one, and, being carried under the vessel to be raised, entered like openings in the other, and were carried to the windlasses on deck. When used, a sufficient quantity of water to sink them to the required depth was admitted into the two halves of the camel; the ropes were cast loose, and the vessel conducted between them. Large beams were passed horizontally through the port-holes, with their ends resting on the camel on each side. The ropes were made fast, the ship secured between the two parts of the camel, and the water pumped out, when they, of course, rose, bearing the ship up with them. By this apparatus, a vessel could be raised from four to six feet.

A primitive arrangement of this sort was used by Perry in 1813, by which he succeeded in getting his two largest vessels, which drew too much water to cross the bar, out of the harbor of Erie, Penn., in the face of the enemy. The guns, loaded and shotted, were whipped out, landed, and placed in battery on the shore.

A large scow was placed on each side of the vessel and filled with water; beams were passed through the ports, resting on blocking in the sunken scows, which were then pumped out, raising the vessels several feet.

The camels used by Colonel Gowen, in removing the sunken vessels which obstructed Sebastopol harbor, had a lifting-power of 5,000 tons. They were nearly submerged, and then connected by chain-falls to a vessel, through the ports or under the bottom. Being then pumped out, the vessel was raised, and floated to shallower water, when the process was repeated, and so on.

2. (*Stocking-frame.*) A bar mounted upon four wheels, and capable of being drawn forward and backward through a small space. Upon it are mounted the *jacks* with their springs, and the *slur-bar* upon which traverses the *slur* by which the jacks are actuated successively.

Cam′e-o. 1. Salient, as opposed to *intaglio*.

2. A stone or shell carved in relief.

The peculiar feature required in the material is that it shall have parallel layers of different colors. Some varieties of chalcedony fulfill this requisition, as the *agate*, which is striped and has layers of varying curvatures, and sometimes curiously contorted strata around a general center.

Another chalcedony is the *onyx*, which has parallel layers of varying colors, and is considered the choicest material for cutting cameos.

The commoner material for cameos is the conch-shell (*strombus*), a mollusk found in many parts of the world, and having two distinct layers of different colors and character. The inner layer is dark-colored, black in the finer specimens from the West Indies and South America, and pink in other specimens, which are not so highly prized, as being less like the Oriental onyx.

The *porcelanous* or inner portion is very hard and intractable to tools of steel. It is dark, and forms the basis or ground of the picture, which is cut in the *nacreous*, whiter, exterior portion, which yields readily to graving-tools.

In dividing the shell into pieces of suitable size for the purpose intended, the lapidary's slicer is used, furnished with diamond dust or some abradant of sufficiently hard grit. Whatever may be the material employed, the figure is cut in one layer upon the other layer as a basis or ground.

The piece of shell is cemented to a block, and is cut by a variety of carving-tools, rather approaching the chisel in their manner of manipulation; the cut being obliquely downwards, to avoid scaling off a layer of the nacreous shell.

The limits of this work forbid detailed artistic description. The work in relief is polished with putty-powder, applied by a tooth-brush.

Engraving in relief on monocolored gems, such as the beryl or emerald, does not fulfill the conditions of the true cameo.

Cam′e-o-in′crus-ta′tion. During the last century the Bohemian glass-makers excited surprise by producing bas-relief casts of busts and medals inclosed within a coating of white flint-glass, and an extension of this art was subsequently patented in England. The process consists in making the article to be incrusted of less fusible materials than those of which the glass by which it is incrusted is composed. A mixture of China clay and silicate of potash is found to answer this requirement. The bust or bas-relief is made of this material in a plaster mold, and after being slightly baked is gradually cooled. A mass of transparent glass is blown hollow, with one end open, and the clay cameo, heated to redness, is placed within it. The mass is pressed or welded to make the two substances adhere, and the glass-blower draws out the air from within, thus causing the glass to collapse and to firmly unite with the cameo. When the glass is cut and polished to any desired form, the effect produced is striking and beautiful; for the clay cameo or bust has the appearance of unburnished silver isolated in the midst of the solid, transparent glass. Small articles are incrusted in a more expeditious manner, especially upon glass goblets or similar hollow vessels. The hot cameo is placed upon the hot vessel, a small piece of semi-liquid glass is dropped upon it, and this both fixes the cameo in its place and forms a glassy layer to inclose it.

Cam′e-o-type. (*Photography.*) A fanciful name given to a small vignette daguerreotype for mounting in a jeweled frame like a cameo.

Cam′e-ra. The cameras used in photography are known by names which indicate construction or purpose. They are, —

Folding, so as to be portable.

Expanding; the front part is rigid and carries the lens, the after part slides on the front part, and carries the dark slide and focusing-screen.

Bellows-camera; the front and after sides connected by a flexible cover.

Copying-camera.

Solar camera; the sun's rays are transmitted through a transparent negative.

Stereoscopic camera; two cameras in one, taking two pictures on the same plate. A substitute arrangement is that in which the camera receives successive positions on one stand with two stations.

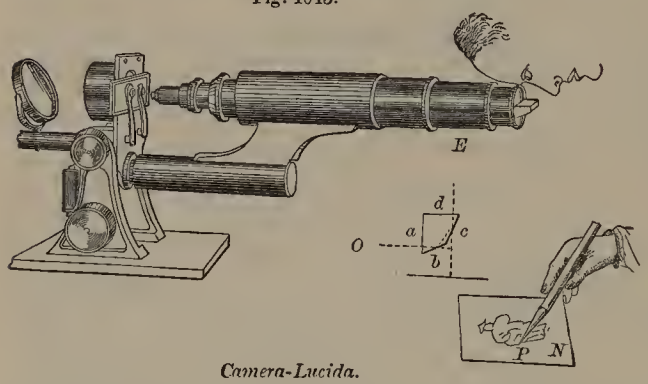
Panoramic camera, one in which a picture may be taken upon one flat, including an angle of 90° more or less. Invented by Sutton. See also PHOTOGRAPHIC CAMERA.

Cam′e-ra-lu′ci-da. Founded upon the invention of Baptista Porta (1589), by Dr. Hooke, about 1674. Improved by Wollaston, 1805. Phil. Trans., Vol. XXXVIII. p. 741.

It consists of a glass prism *a b c d*, by means of which rays of light are bent by two reflections into a path at right angles to their previous direction. A ray of light proceeding from *O* enters the face of the prism at *a*, is reflected by *b* and *c* till it assumes the direction *c E*, at which latter point is the eye of the observer.

As a contrivance of Dr. Wollaston, for the purpose of delineating a microscopic object, it consists of a prism fitted on the front of the eye-piece of the microscope *E*, in place of the *cap* by which it is usually surmounted. The rays passing through the eye-piece into the prism are reflected from its oblique surface and come to its upper horizontal surface at right angles to their former direction, and

Fig. 1043.



Camera-Lucida.

the eye receives them with a part of the pupil, while it looks beyond the prism, with the other part of the pupil, to a white paper surface *N*, on the table, and the hand follows with a pencil-point, *P*, the outlines of the object apparently projected thereon. The image and the paper occupy the same field, and the image, therefore, is apparently displayed upon the paper.

The optigraph is an instrument for the same purpose, but of different construction. See OPTIGRAPH.

Cam′e-ra-ob-scu′ra. The invention of this instrument has been credited to Roger Bacon, 1297, and to Alberti, 1437. It was described by Leonardo da Vinci, in 1500, as an imitation of the mechanical structure of the eye. The theory of optical sensation was laid down by Alhazen the Saracen, A. D. 1100. See BINOCULAR GLASSES.

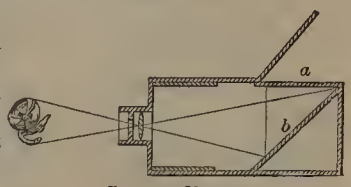
Baptista Porta, in 1589, mentions it in his book on "Natural Magic." Sir Isaac Newton remodeled it, 1700. Daguerre, in 1839, rendered the images obtained therein permanent, after Wedgewood, Davy, and Niepce had only partially succeeded. See PHOTOGRAPHY.

The camera-obscura as described by Baptista Porta is a dark chamber of cylindrical form, with a lens at one end and a white card or paper at the other, so placed as to be within the focus of the glass upon which the external image is depicted.

The instrument, for the uses of photographers, has been enlarged and improved. Achromatic and periscopic glass have been employed; facilities for adjustment in hight, angle of presentation, and for focus, and arrangements for introducing and withdrawing the slides. See PHOTOGRAPHIC CAMERA; SOLAR CAMERA, etc.

Before the photographic art had attained any celebrity, the camera was sold in the stores of opticians in a portable form, and used in taking sketches from life and from nature.

Fig. 1044.

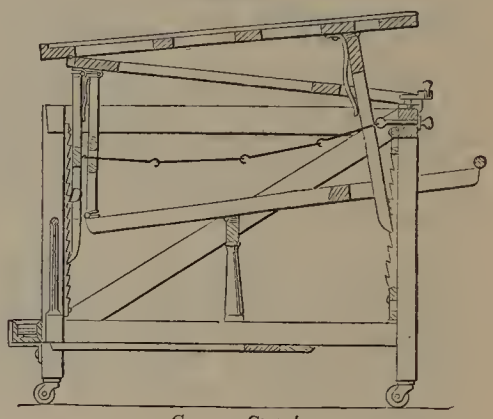


Camera-Obscura.

The beams of light enter at the lens in front of the box, and the image of the objects in the field are reflected by the mirror *b* against the under side of the ground glass *a*. The outlines of the objects are then traced on the ground glass, or on a sheet of paper sufficiently transparent for the purpose.

Cam′e-ra-stand. (*Photography.*) A frame on which the camera rests, and which is adjustable, to vary the hight, horizontal presentation, or inclination of the optic-axis as may be required. In the example, the elevation and inclination of the camera-platform are obtained by a compound arrangement of lifting-bars, ratchets, and pawls, acting within and upon a frame mounted on casters.

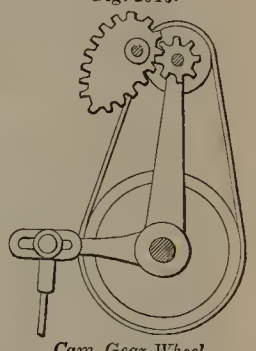
Fig. 1045.



Camera-Stand.

Cam-gear Wheel. An arrangement of gearing.

Fig. 1046.



Cam-Gear Wheel.

1. The motion of the cam-shaped cog-wheel being continuous, and the rotation of its axis in uniform times, the speed imparted to the pinion is variable, and the respective axes alternately approach and recede as the cogged cam revolves.

2. The motion being derived from the pinion by the band from the drum, the meshing of the pinion with the cogged cam will give a variable vibrating movement to the bell-crank and to the rod connected thereto.

Ca′mi-on. A heavy dray for the transportation of ordnance.

Cam′let. (*Fabric.*) A cloak-stuff formerly made of camel's hair, alone or mixed with silk; since made of wool and silk or wool and flax. It was a fashionable cloak stuff in the days of our fathers and their fathers. It was rigid from close weaving, and nearly waterproof. It went out when india-rubber fabrics came in.

Camel's-hair cloth is used for tent coverings in Algiers by the Kabyles and Berbers; in China for carpets; in Turkey for soldiers' coverlets; in Circassia for dreadnaught cloaks. Fine or coarse, its uses are great and various. Marco Polo refers to this manufacture at the city of Kalaka, in the province of Tangut, in the domain of the great Genghis Khan.

"After dinner, I put on my new camelott suit; the best I ever wore in my life, the suit costing me above £24" (*Pepys's Diary*, 1665). This was a rich silk.

"This night my new camelott riding coate to my colored cloth suit came home" (PEPYS, 1662). This latter was possibly not "my gray cloth suit and faced white coate, made out of one of my wife's petty-coates."

Ca-mou'flet. (*Fortification.*) A small mine or countermine charge intended to blow in the side of a gallery.

Cam'pa-ni'le. (*Architecture.*) A bell-tower, principally used for church purposes, but now sometimes for domestic edifices in the Italian style.

Fig. 1047.

Campanile.

Camp-bed. A bedstead for the use of military men or travelers; they are variously constructed, the object being lightness and economy of space for facility of transportation, and are usually made of iron. A *cot*.

Camp-ceil'ing. (*Architecture.*) One in which the marginal portion is sloping, following the line of the rafters, while the mid-portion is level.

Camp-chair. A form of folding chair adapted to be carried by a pedestrian, or packed away in an ambulance or wagon when on the march. See FOLDING-CHAIR.

Camp-kit. A box, with its contents, for containing soldiers' cooking and mess utensils, such as the camp-kettle, plates, etc.

Camp-mill. A mill adapted for the use of an army, to grind grain on the march or in camp. It is carried on a wagon or running-gears, and is sometimes driven by the wheels in traveling; sometimes by a sweep operated by horses or men after the wheels are anchored or sunk in the ground.

The first portable mill thus adapted to its own carriage appears to have been invented by Pompeo Targone, engineer to the Marquis Ambrose Spinola, about the end of the sixteenth century. See GRINDING-MILL; HAND-MILL.

Camp-ta'ble. One adapted to fold into a small space for transportation.

Camp-sheet'ing. (*Hydraulic Engineering.*) A piling erected at the foot of an embankment to prevent the out-thrust, or the washing by the current or waves.

It consists of guide-piles exteriorly, against which are placed wale-pieces, which are horizontal timbers. Within these are driven vertical planks of the nature of pile-sheeting.

Camp-stool. A chair whose frame folds up into a small compass for convenience of packing or carriage. Camp-stools were known in ancient Egypt, and were constructed in a manner similar to ours. They frequently occur in the paintings, and some have been preserved till our time. One found at Sakkarah is in the Abbott Collection, New York. See CHAIR; FOLDING-CHAIR.

Camp-stove. A light sheet-iron stove, specially arranged with a view to portability, and adapted for heating a tent or hut, and for cooking purposes.

Camp-tu'li-con. (*Fabric.*) A compound used as a substitute for carpet or oil-cloth.

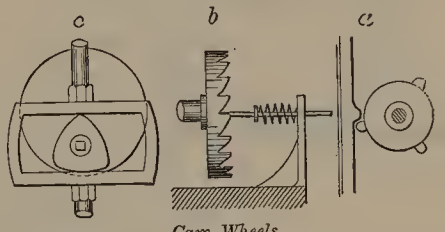
It is made by a combination of powdered cork and the poorer qualities of india-rubber, and is painted or ornamented on the surface like oil-cloth. It is not suitable for chambers, as being a good conductor of heat, and feeling as cold to the bare feet as wood or oil-cloth. A convenient application of this substance is for cleaning knives, and is made by covering a strip of wood with it; then sprinkling the surface with the cleaning powder, and rubbing on the knife. The surface does not wear away, and the result is very satisfactory.

Cam-shaft. A shaft having *cams* or *wipers*, for raising the pestles of stamping-mills. A *tumbling-shaft*, or *wallower*. See CAM-WHEEL.

Cam-wheel. A wheel with a projection (or projections) either on the periphery or face, adapted to give motion to another object against which it impinges by sliding contact. The *wiper*-wheel is an example (which see).

In the illustration, *a* represents the cam-wheel as lifting a stamp-rod or beetle; in *b* the duty of the cam-wheel is to give an intermittent, reciprocating motion to the bar, which is returned by a spring after each impulse. Their forms and applications

Fig. 1048.



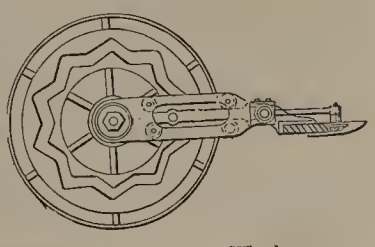
Cam-Wheels.

are very various, and the actions of the heart-wheel and eccentric are substantially similar. The *heart* is a cam with a regular motion, so as to produce a back and forward reciprocation in equal times without any sharp percussive action; differing in this respect from the action of the two preceding and from that of the tilt-hammer. See HEART-WHEEL.

c is a cam and yoke in use in France for the valve motion of steam-engines. It is used for giving an intermittent, rectilinear reciprocating motion. The circular disk carries the cam; the valve has a momentary rest and then a rapid motion, a single stroke and return for each revolution of the disk.

Fig. 1049 is an illustration of a cam-wheel having a waving slot *through* the wheel, in which traverses a roller on a bar, which communicates a reciprocating motion to the cutter-bar of a harvester.

Fig. 1049.

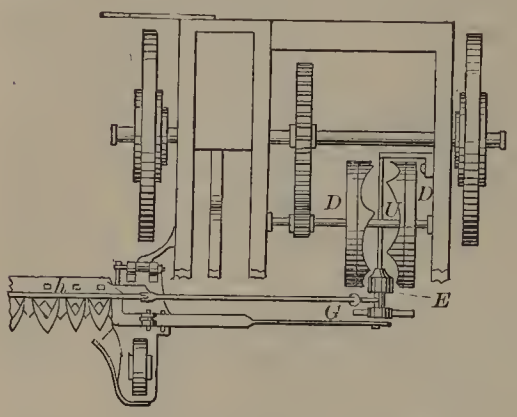


Cam Harvester-Wheel.

In Fig. 1050,

the cams are on the *faces* of the wheels *D D*, consisting of a double series of inclined curves, between

Fig. 1050.

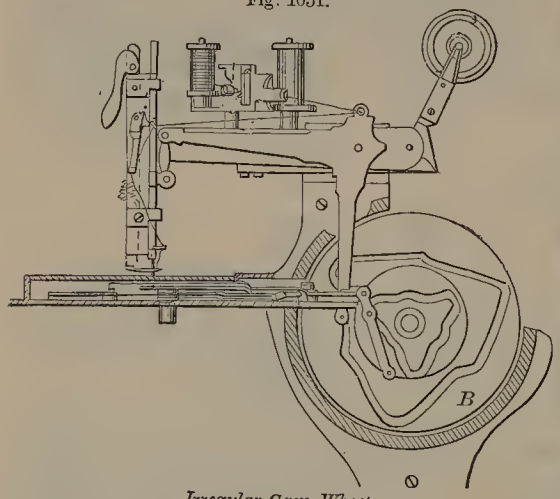


Double Cam-Wheel.

which is the race *U* of the roller *E*, whose oscillation in its track gives the reciprocation to the rod *G* on the end of the cutter-bar.

Fig. 1051 shows a disk *B* having irregular face-grooves, by which are actuated the bell-crank levers

Fig. 1051.



Irregular Cam-Wheel.

of the needle-carrier and feed-bar of a sewing-machine.

Can. 1. A sheet-metal vessel for containing liquids, etc. Cans are commonly cylindrical, but for some purposes are made square or of conical form, and provided with a handle and spout, as oil-cans for lubricating purposes.

2. The tin cylinder which receives a sliver from the carding-machine. It revolves upon a center eccentric to the center of motion of the delivering surfaces, thereby causing the sliver to arrange itself in a series of coils throughout the area of the can ; as the can is filled, it rises against a plate at the top, and as the operation proceeds is pressed down and condensed.

Cans derive their names sometimes from peculiarity of construction or material, but more usually from their purpose or intended contents ; such as —

Caustic alkali.	Oil.
Fruit.	Oyster.
Gunpowder.	Paint.
Milk.	Preserve, etc.

Ca-nal'. An artificial channel filled with water, and designed for navigation.

The term is also sometimes applied to narrow straits or inlets of the ocean.

Egypt and Assyria bear the palm of priority in canals. Their immense plains were early irrigated by water from the rivers Nile, Euphrates, and Tigris. The main arteries of their network of water-courses became the avenues for the transportation of produce.

The great canal which united the Nile to the Red Sea was dug by the orders of Sesostris (1500 B. C.) according to Strabo, Pliny, and Aristotle ; so that China is fairly anticipated for once, as the Great Canal of China was not made till the ninth century A. D., about the time of Charlemagne.

The Egyptian canal commenced about twelve miles above the modern town of Belbays, the *Bubastis Agria* of the Romans. It was about 96 miles long, and was on the point of being abandoned several times, as it was feared that the fresh water of the Nile would be ruined by the salt water of the Red Sea, which has several feet greater elevation than the usual level of the river. The difficulty was avoided by some hydraulic contrivance, according to Diodorus Siculus and Strabo. The word is translated SLUICE (which see). It was probably an inclined chute.

The canal built by Sesostris was reopened by Pharaoh Necho about 605 B. C., by Ptolemy Philadelphus about 300 B. C., by the Cæsars, by the Caliphs ; and was abandoned when Vasco de Gama circumnavigated the Cape of Good Hope.

The canal which conducted the water of the Nile to Lake Mœris during half the year, and distributed it during the other half for the purpose of irrigation, was a stupendous work, and, according to Savary, was forty leagues in length. Two additional canals were also provided with sluices, which governed the influx and efflux. Diodorus Siculus also describes the canal. His measurements differ from the modern ones.

Herodotus states that the Lake Mœris was excavated 1385 B. C., and was 450 miles in circumference. It was probably a natural basin artificially adapted as a reservoir to be filled during high Nile.

Nebuchadnezzar constructed a canal 400 or 500 miles long, running from Hit, the Is of Herodotus, to the Bay of Graine, on the Persian Gulf. It is referred to by Strabo (XVI. 1052). It has been traced by Colonel Rawlinson from Hit almost to the Bay of Graine.

Herodotus and Pliny mention the canals of Asia Minor. The first constructed in Europe was probably that dug by Xerxes across the low Isthmus of Athos. The Greeks attempted to cut one across the Isthmus of Corinth.

Among the early European canals may be mentioned the canal through the Pontine Marshes, made 162 B. C. ; and the Fossa Phillistina and Carbonania, dug by the Etruscans, and which derived their water from the Padus, now the Po.

Caius Marius, 51 B. C., constructed the Fossa Marina between Arles and Fos, a haven on the Mediterranean.

Lucius Verus undertook to unite the Saone and Moselle, and also to unite the Mediterrancan and the German Ocean by means of the Rhone, Saone, Moselle, and Rhine. His death prevented the execution of the project.

The great object of the Romans was to increase the facility of transportation, the great economical agent of civilization. Their land and water ways were the arteries and veins of commerce, and the

ligatures which bound the provinces to the metropolis and the state.

The Rhine had in early Roman times but two outlets; Virgil calls it *bicornis*, and Tacitus says that the largest of these branches, that nearest to Gaul, is called *Vahalum*. In the days of Charlemagne the Rhine communicated with the Escaut by a branch of the Meuse which has since disappeared. A great inundation, A. D. 860, obliterated many minor channels near the efflux, and opened new ones. In the thirteenth century the Zuyder Zee was converted from an inland fresh-water lake into a gulf of the sea by a storm which destroyed the barrier between it and the latter. The Roman legions under Drusus, B. C. 12, dug a canal between the Rhine and the small river Sala, as a military defence; this became enlarged into a third branch of the Rhine; it is mentioned by Pliny. A fourth branch, the Leek, was created subsequently, in a similar manner, during an insurrection under Claudius Civilis.

When the Roman Empire fell to pieces, all engineering enterprises ceased, and the completed works fell into decay. Charlemagne revived the project of uniting the Rhine and the Danube, so as to connect the German Ocean and the Black Sea.

The first canal in England was the Caerdike, cut by the Romans.

Canals were constructed in China before the Christian era. No mention is made of canals in the Bible. The largest hydraulic works therein mentioned are those of Solomon, who introduced abundant water for baths, gardens, and fish-ponds, — aqueducts, not canals.

The largest canal in the world is the Imperial Canal of China, which extends southward from Pekin and unites the Pei-ho with the Yang-tse-Kiang. A part of the canal was constructed in the seventh century, and a part in the ninth, A. D. It is 825 miles long, and with its connected rivers gives an inland navigation of 2,000 miles, and connects 41 cities. Authorities differ as to whether the Chinese canals overcome grades by locks or inclined planes. It is to be presumed they have both.

From the twelfth to the fifteenth centuries canals in the Netherlands were made in great numbers.

The ship-canal, 51 miles in length, whereby the commerce of Amsterdam reaches the ocean, is wide and deep enough to float two passing frigates. It was built 1819–25, at a cost of $4,250,000. A still deeper and wider one is now in progress.

Previous to the invention of canal-locks by the brothers Domenico, sluices were employed in Italy. These were boarded conduits, forming chutes down which the vessel slid or floated; a gate at the upper end being lifted for the entrance of the vessel, and restored again to form a dam to preserve the upper level.

Movable gates to restrain the water on the higher level and admit the passage of boats were introduced in the navigation of the Tesino and Adda to Milan.

Cresy dates the invention of canal-locks to 1188, when Pitentino restored the Mincio to its ancient channel to the Po, from whence it had been diverted by the Romans in the time of Quintus Curtius Hostilius.

The canal of Languedoc, which unites the Garonne with the Mediterranean, passes across the narrow portion of France north of the Pyrenees, and is 150 miles in length. It unites the Atlantic and Mediterranean, and was constructed by Andreossy, an Italian engineer, in the reign of Louis XIV. The fall from the summit at Naurouse to Cette, on the Mediterranean, is 621 feet 6 inches. The fall from the summit to the Garonne is 198 feet. There are 74 locks on the eastern portion, 26 locks on the Atlantic section, which ends at Toulouse, on the Garonne; 100 locks in all.

The surface of the canal is 64 feet broad; the bottom, 34 feet; the depth, 6 feet 4 inches. The canal-boats are 80 feet long, 18 feet broad, draw 5 feet 4 inches of water, and carry 100 tons.

The canal cost $6,000,000.

The canal of Charolais unites the Loire and Saone, which, at one place, approach within eighteen leagues of each other, and fall into the Bay of Biscay and the Mediterranean respectively. The project was agitated as early as 1555, and various surveys and reports were made, as well as several commencements attempted. The lavish expenditure upon the buildings and parks for the personal aggrandizement of Louis XIV. delayed the works of public utility, and it was not till near the end of the last century that it was opened. Its length is 114.322 metres.

The canal uniting the Somme and the Scheldt was undertaken in 1776 and completed in 1810. The length is 32½ miles.

The canal of Orleans is 45 miles long, uniting the Loire and the Seine.

The canal between the Baltic and North Seas at Kiel was opened 1785. That from the Cattegat to the Baltic, 1794–1800. The main line of the Ganges Canal, 525 miles long, for irrigating the country between the Ganges and the Jumna, was opened in 1854. When completed, it will be 900 miles long, and will irrigate 1,470,000 acres. Its estimated cost is £1,555,548. Sir Proby Cautley, engineer.

The canal in England joining the Trent and the Witham was made A. D. 1134, in the reign of Henry I. The Bridgewater Canal commenced in 1759. In England there are 2,800 miles of canals.

Of the American canals: —

The James River and Kanawha, 147 miles long, overcomes the greatest grade, having a lift of 1,916 feet.

The Morris and Essex, 101 miles long, overcomes a grade of 1,674 feet, accomplished by 29 locks and 22 inclined planes.

The Erie, by DeWitt Clinton, is the longest, 363 miles, with 84 locks.

The Erie Canal was commenced in 1817, and completed in 1825. The main line leading from Albany, on the Hudson, to Buffalo, on Lake Erie, measures 363 miles in length, and cost about $7,200,000. The Champlain, Oswego, Chemung, Cayuga, and Crooked Lake Canals, and some others, join the main line, and, including these branch canals, it measures 543 miles in length, and cost upwards of $11,500,000. This canal was originally 40 feet in breadth at the water-line, 28 feet at the bottom, and 4 feet in depth. Its dimensions proved too small for the extensive trade which it had to support, and the depth of water was increased to 7 feet, and the extreme breadth of the canal to 60 feet. There are 84 locks on the main line. These locks, originally 90 feet in length and 15 in breadth, and with an average lift of 8 feet 2 inches, have since been much enlarged. The total rise and fall is 692 feet. The tow-path is elevated 4 feet above the level of the water, and is 10 feet in breadth. At Lockport the canal descends 60 feet by means of 5 locks excavated in solid rock, and afterwards proceeds on a uniform level for a distance of 63 miles to Genesee River, over which it is carried on an aqueduct having 9 arches of 50 feet span each. Eight and a half miles from this point it passes over the Cayuga marsh, on an embankment 2 miles in length, and in some places 70 feet in hight. At Syracuse, the "long level"

commences, which extends for a distance of 69½ miles to Frankfort, without an intervening lock. After leaving Frankfort, the canal crosses the river Mohawk, first by an aqueduct 748 feet in length, supported on 16 piers, elevated 25 feet above the surface of the river, and afterwards by another aqueduct 1,188 feet in length, and emerges into the Hudson at Albany.

The widest are the Cornwall, Beauharnois, and Lachine (Canada), being respectively 12, 11, and 8½ miles long, and 150, 190, and 120 feet wide. Each has a depth of 10 feet, and locks 200 feet long, respectively 55, 45, and 55 feet wide. The most costly per mile is the Lachine (Canada), 8½ miles long, cost $2,000,000 ; $235,934 per mile. The Chesapeake and Delaware cost $203,703 per mile. The cheapest per mile is the Ohio and Erie, 307 miles long, $15,300 per mile. The greatest number of locks are on the Schuylkill Canal, 108 miles long, 120 locks.

The Welland (Canada), 36 miles long, admits vessels of a tonnage of 500 tons. The locks have double the capacity of any other. Cost, $7,000,000.

The Suez Canal connects the Mediterranean and the Red Sea, thus uniting the Atlantic and Indian Oceans, and saving the immense *détour* around the continent of Africa formerly necessary to reach the Indies from any portion of Europe. The length of the canal is about 90 miles, having a depth of from 20 to 26 feet, and a width of from 180 to 300 feet, sufficient to accommodate vessels passing each other on the transit from ocean to ocean. The total cost of this canal, with the necessary docks, etc., was about $100,000,000.

In the making of the Suez Canal, the total amount of earth removed amounted to about four hundred million cubic yards. By working day and night, the machines of M. Borel and Lavelley were able to remove 78,056 to 108,000 cubic metres per month.

After ten years of labor this great work was completed. Upon the 17th of November, 1869, the opening of the canal was inaugurated in the presence of the Empress Eugenie and the Emperor of Austria, and of princes, ambassadors, and men of science from Europe and America.

The transit between the two seas was safely made by the fleet. But the requisite depth had not been attained. Seventeen and a half feet of draft could be carried through the canal. Since then the depth has been increased to twenty-two feet, and ultimately will be twenty-six feet.

The length of the canal is 100 miles. The established surface-width is about 328 feet, except in difficult cuttings, where it is 190 feet. The least bottom width is 72 feet. The highest ground cut through is at El Guisr, where it is 85 feet ; at Serapeum it is 62 feet ; and at Chalouf, near Suez, it is 56 feet.

The excavation of the canal, although of considerable difficulty, was exceeded by the necessity for creating artificial harbors at the extremities. The harbor at Port Said, upon the Mediterranean, has the general form of a triangle, the base resting on the shore and the longer side on the west, protecting the entrance from the moving sand. The longer arm or mole is 8,200 feet, extending to the 26-feet curve of sounding. It is proposed to extend this mole 2,300 feet farther. As this harbor is exposed to northeast winds, an inside basin has been constructed. The area of the outer harbor is equal to 400 acres, and will permit twenty line-of-battle ships to swing freely at anchor.

At the other extremity of the canal, a mole 2,550 feet in length protects the channel, which has been dredged to the depth of 27 feet. The mole at Suez differs from that at Port Said in construction ; the latter being formed of concrete blocks of 13 cubic feet, the former of stone quarried from the neighboring mountain.

The following is a summary of the expenditures up to the date of the opening of the canal : —

General expenditures for preliminary surveys from 1854 to 1859 . .	$15,825,525
General expenses of administration and negotiations between France and Egypt	3,394,245
Sanitary service, 1866–1869 . .	121,410
Telegraph service	34,000
Transport service, boats, stock, buildings	1,644,435
Payment of contractors for material	3,442,785
Dredging-machines and heavy plant .	6,819,240
Workshops	844,150
Works of construction, canal, and ports	43,534,330
Miscellaneous	1,392,495
Expenses of various branches of company management	3,841,050
	$80,893,665
The average cost of the canal per mile is	$808,936

This magnificent work is a better scheme than the proposition of another Frenchman ; to dig a canal from the Bay of Acre to the water-shed of the Jordan, and across the water-shed between the Dead Sea and the Gulf of Akabah, thus uniting the Mediterranean with the Red Sea.

The depression of the valley of the Jordan is a long narrow basin, 200 miles in length and about 20 in breadth. About one fourth is now covered with water. It includes the Dead Sea and the Lake of Tiberias, which are 60 miles apart, and the river Jordan, by which they are connected. The depth of the ordinary surface of the water in the Dead Sea is 1,388 feet below the Mediterranean water-level, and the depth of water in the deepest part of the Dead Sea is 1,350 feet ; showing the total depth of this great depression to be 2,738 feet below the Mediterranean level. The land adjacent to the sea, however, is a table-land 3,000 feet above the Mediterranean, so that the whole depth of this great natural gorge is about 6,000 feet. The gorge is continued through the Red Sea into the Indian Ocean, but a ridge 113 feet above the Red Sea separates the waters of the Gulf of Akabah from those of the Salt Lake. The fissure, with the exception stated, may thus be said to extend from Mount Hermon to Akabah, 350 miles, and thence to the Straits of Babelmandeb, 1,200 miles farther.

The water of the Red Sea has a few feet elevation above that of the Mediterranean, which would make a water-fall of 1,400 feet depth if the water-shed at the north end of the Gulf of Akabah were to be cut through, allowing the gorge to fill with the waters of the south.

This would add about 1,400 feet depth of water to the Dead Sea, and would put the lower end of the Jordan that far under water. The city of Tiberius would be submerged 600 feet below the surface of the salt water, and the waters would ramify among the hills of Judea and the affluents of the Jordan till they found themselves checked by the mountains of "the land of Zebulon and the land of Naphtali, beyond Jordan, Galilee of the Gentiles." The sites of Capernaum and Bethsaida would thus experience a part of the fate of Sodom, submergence in salt water, while the Dead Sea would be somewhat freshened.

Aqueducts with cast-iron beds, supported by arches and piers, were introduced by Telford, 1793 –

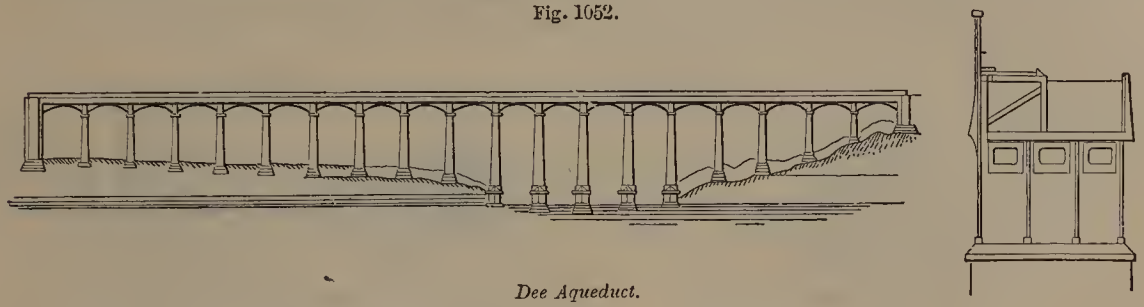
1829, in the construction of several canals; the Shrewsbury, and the Ellesmere and Chester, for instance. The aqueduct over the Ceirog is 710 feet in length, and the water surface 70 feet above the level of the river; ten arches have each 40 feet span. The breadth of the top is 22 feet; breadth of water, 11 feet; depth, 5 feet.

The stone piers are 33 feet in depth and 13 in thickness; the spandrels have longitudinal walls, supporting the cast-iron plates which form the bottom of the canal. The plates have flanges on their edges, and are united by means of nuts and screws.

The sides of the canal are built of cut-stone upon the cast-iron bed; they are 5½ feet thick on each side, and the stone is backed with hard-burned brick laid in cement. The sides have iron railings. It was completed in 1801, and cost about $100,000.

Another aqueduct on the same canal, the Ellesmere and Chester, at Pont-y-Cysyllte, is 1,007 feet long, and the water-level is 127 feet above the waters of the Dee. It has 2 abutments and 18 piers. The piers are founded on sandstone rock, are 12 × 20 feet at the bottom, and 7½ × 13 feet at the top. For 70 feet of their hight they are solid, and the remaining 50 hollow, the walls being 2 feet in thickness, with one inner cross-wall. The width of the water-way is 11 feet 10 inches, of which the towing-path covers 4 feet 8 inches, leaving 7 feet 2 inches

Fig. 1052.



Dee Aqueduct.

for the boat. The towing-path stands upon iron pillars, and the water flows beneath it.

The embankment cost about . .	$42,000
Masonry	105,000
Iron-work	85,000
	$232,500

In this aqueduct, the sides, as well as the bottom, are made of cast-iron. The arches have a span of 45 feet, and a rise above the springing, 7 feet 6 inches.

Canals are classed as: —

Level or *ditch* canals; consisting of one reach, level throughout.

Lateral canals; which connect places in the same valley, the fall being in one direction only.

Summit canals; in which the work crosses one or more summits, at which provision of water must be supplied.

Canals are now projected: —

To turn Lake Michigan into the Mississippi. This is under way.

Across the Isthmus of Corinth. This, as has been remarked, was projected 600 B. C. It attracted the attention, also, of Demetrius Poliorketes, Julius Cæsar, Caligula, and Herodes Atticus; but it was reserved for Nero to take the first active step toward the accomplishment of this end. He completed a canal for a distance of 3,683 feet on the Corinthian, and 6,946 feet on the Savonian, side of the isthmus.

This important historical fact has been lately ascertained through the investigations of Mons. Grimaud de Caux. The entire width of the isthmus at that point amounts to about 18,799 feet, so that it would seem the canal was more than half cut through. A canal across the Isthmus of Corinth would shorten the route from Trieste to Athens forty-one hours for sailing-vessels, and fifteen hours for steamers; from Marseilles to Athens fourteen hours for sailing-vessels and five hours for steamers; and, finally, from Gibraltar to Athens six hours for the former and two and a half for the latter.

A large ship-canal to connect the Baltic and North Seas. There are now two small ones across the Isthmus of Holstein, — the Streckenitz Canal, 1390 – 98, between the Elbe and the Trave; and the Schleswick Holstein, or Eyder Canal, 1777 – 84, between Kiel, on the Baltic, and Rendsburg, on the Eyder.

Ca-nal'-boat. A large boat, generally decked, and towed by horses; they vary in capacity, according to the width and depth of the canal on which they are employed. The usual capacity of those on the Chesapeake and Ohio Canal, one of the widest and deepest in the United States, is 110 to 115 tons of coal.

Rankine states that the heaviest boat one horse can draw at a speed of from 2 to 2½ miles per hour weighs with its cargo 105 tons, is about 70 feet long, 12 feet broad, and draws 4½ feet of water.

A boat to be drawn by one horse at the rate of 3½ to 4 miles per hour will be about 70 feet long, 6 or 7 broad, and draw about 2½ feet of water.

Ca-nal'-bridge. A bridge adapted to form a viaduct above the water-way. Movable canal-bridges may be of one of the following kinds: —

1. Turning horizontally. See SWING-BRIDGE; PIVOT-BRIDGE.

2. Turning vertically. See BASCULE-BRIDGE.

3. Rolling horizontally and in the direction of its length; one form of *drawbridge*.

4. Lifting vertically. See LIFT-BRIDGE.

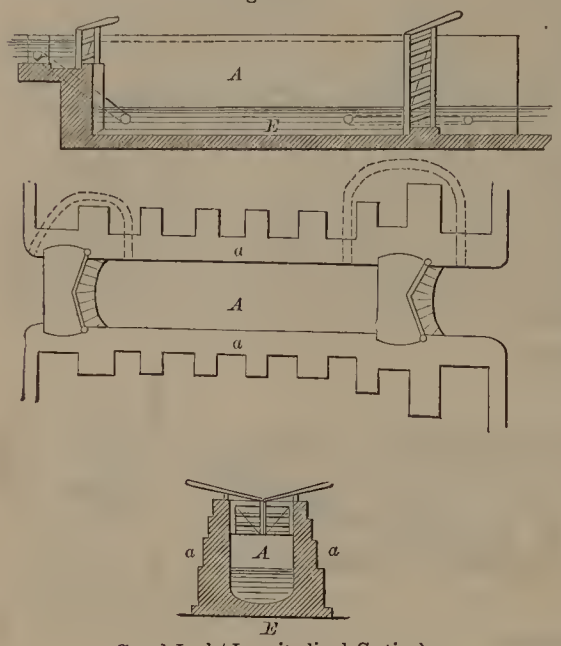
5. Floating in the canal and withdrawn into a dock to allow masted boats or vessels to pass. See FLOATING-BRIDGE.

Ca-nal'-lift. A contrivance for conveying a canal-boat from one level to another without the use of water in the usual lock. It may be of the nature of the slip or marine railway, such as used on the Morris and Essex Canal, N. J., or it may be a mechanical lift by means of tackle. In one case it is proposed to float the vessel in a caisson which is supported in level position on a wedge-shaped frame which traverses on the ways.

Ca-nal'-lock. An inclosure with gates at each end, forming a connection between the upper and lower levels of a canal.

In the accompanying drawings, *A* is the *lock-chamber*; *a a*, the side walls; *E* the floor, or *invert*. The size of the chamber is a little longer than the longest boat required to occupy it; its breadth say 1 foot wider than the said boat; its depth 1½ more

Fig. 1053.



Canal-Lock (Longitudinal Section).

than the draft of a loaded boat plus the lift, and, say, 2 feet added for the coping.

The floor is level with the bottom of the lower reach, and is recessed, for the opening of the *tail-gates*. The *head-bay* has *side walls* having *gate-chambers* to receive the *head-gates*. The floor is level with the upper *pond*.

The sides of the tail-bay end in curved wings, and the *floor* or *apron* is pitched with dry stone.

At the head of the *lock-chamber* is the lift-wall, above which are the *head-gates*, whose lower edges press against the *head miter-sill*.

The *tail-gates*, which close against the *tail miter-sill*.

The culverts through the side walls shown in dotted lines are for filling or emptying the lock-chamber. These sluices are governed by slide-valves.

The cylindrical recesses in the side walls in which the gates are hinged are called *hollow quoins*.

Each gate is composed of a *heel-post*, *miter-post*, *balance-bar*, *cross-pieces*, *eleading*, and *diagonal bracing*.

There was a lock at London Bridge in Pepys's time, 1661; at least, he calls it such. It was probably a sluice, and the chatty fellow "was fain to stand upon one of the piers about the bridge, before the men could drag their boat through the lock."

Ca-nal'-lock Gate. The hinged doors at each end of a canal-lock, which are opened and closed to admit the passage of vessels. Of these there are two at each end of the lock. They are hung on pintles in the stone-work, and open outwardly, being turned by levers, similar to the tiller of a rudder, and when closed the two edges must fit as accurately together as possible to prevent the passage of water.

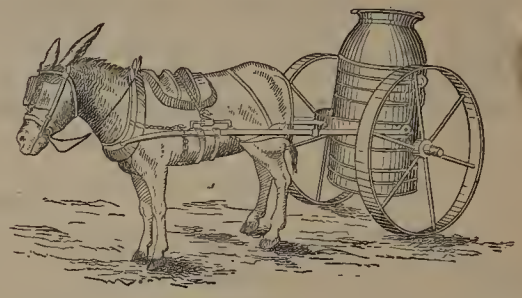
At least one gate at each end must be provided with a sluice or flood-gate near its bottom. When a boat is to pass from a higher to a lower level in the canal, the gates at the lower end are closed, and water admitted into the lock at the other end until the water in the lock is at the same hight as that of the canal above; the upper gates are then opened, and the boat admitted into the lock, when these gates and their sluice are closed. The water is then drawn from the lock by the sluice in the gate at the lower end, and when the water in the lock is at the hight of the lower level, the lower gates are opened, and the boat allowed to pass out.

To elevate the boat from a lower to a higher level, the water in the lock is brought to the lower level by opening the sluice at that end, if necessary, the gates being then opened and the boat passed in, these gates are again closed, and water admitted by the upper sluice until a sufficient hight is attained, when the upper gates are opened and the boat passed out of the lock.

Can-buoy. (*Nautical.*) A conical buoy. See Buoy.

Can-cart. A lightly framed two-wheeled vehicle supporting a large can for containing milk, etc.

Fig. 1054.



Can-Cart.

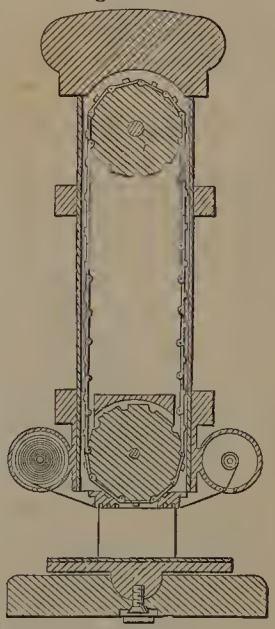
The illustration gives a clear idea of the arrangement.

Can'cel. A leaf to be cut out and replaced by a corrected page.

Can'cel-li. Among the Romans, iron gratings and trellis-work; in modern buildings, latticed windows made with cross-bars of wood, iron, lead, etc.

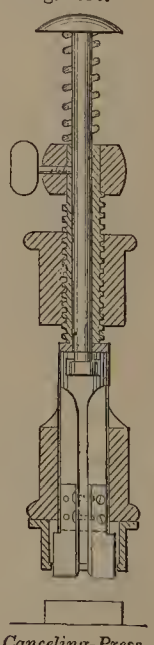
Can'cel-ing-press. A press having a plunger which defaces a printed stamp. These presses are usually worked by a blow or by a lever. In some, the face of the stamp is cancelled by printing upon it the date of cancellation, as in the example (Fig.

Fig. 1055.



Canceling-Stamp.

Fig. 1056.



Canceling-Press.

1055, in which a socket in the lower end of the plunger has a type-chase, which may have movable type to indicate month and year inside the motto of the chase, which may be the title, etc., of the firm. A central slot in the face of the chase is occupied by one link of an endless chain, whose consecutive links have type corresponding to the days of the month, and moved in the required succession by sprocket-wheels in the plunger.

In other forms of canceling-stamps the plunger is armed with blades or points, which penetrate and tear the paper of the printed stamp, so that it may not be restorable by a process which would discharge the ink of cancellation.

Such an one is represented in Fig. 1056, which is operated by percussion of the plunger or rotation of the screw.

Can'cel-ing-stamp. A press for defacing printed stamps, to prevent their re-use. See CANCELING-PRESS.

Can'de-la'brum. A lamp-stand. Its tripedal form among the ancients is believed to have been derived from the shape of its predecessors,—braziers or basins for holding fuel, mounted on tripods.

Among the Greeks and Romans they were highly ornamental, and made of bronze and marble. They survived until lately in the branched sticks for the candles whereby halls and stately dinner-tables were illuminated.

"Euphorion, in his 'Historic Commentaries,' says that the young Dionysius, the tyrant of Sicily, dedicated, in the Prytaneum of Tarentum, a candlestick capable of containing as great a number of candles as there are days in the year." — ATHENÆUS, in the "Deipnosophists."

Can'di-teer'. (*Fortification.*) A protection for miners, consisting of brushwood, etc.

Can'dle. A cylinder of tallow, wax, paraffine, stearine, spermaceti, or other fatty material, in the axis of which is a woody wick consisting of parallel, woven, or twisted fibres, or a rush.

We may presume that the earliest forms of portable artificial lights were brands and torches, to which succeeded cressets and lamps. An elevated fire in a brazier or cresset, fed at intervals with inflammable material, such as wood and fatty or oily matters, would be an effective light for Eastern habitations, where the courts are open to the sky. We use its substantial equivalent at camp-meetings. It must be remembered that the uses of artificial light for reading and study are comparatively modern; the universal lighting up of every house as soon as darkness covers the land is a modern necessity and a modern invention. The long winter evenings of previous generations were spent by the light of the fire, not of lamps or candles, so far as the bulk of the people of all lands was concerned. But a very small number could read, and books were so scarce that kings gave security when they borrowed them; Bibles were chained in churches; and there was one law for the man who could read, and another for him who could not, the former being entitled to "benefit of clergy." In reviewing the mode of life of kings 500 years since, in comparatively barbarous England, we find one of the royal Plantagenets sitting on a stool whose three legs were driven into the dirt forming the floor of his bedchamber on the second floor, over the arched ceiling of the common hall below. His queen sits on the foot of the bedstead, and as evening draws on they find themselves sleepy after a heavy supper of beef and beer. As the drowsy king has sworn himself hoarse in recounting to his satellites the hunting adventures of the day, and has no scholastic resources, being unable to read and having no books, he finds time heavy on his hands.

While meditating on the question of whether it is worth while to kick off his boots before going to bed, he is interrupted by a chamberlain, who sleeps above, and has no way of ascending except by coming through the royal apartment. As times were not then what they once were, when the folks scattered themselves promiscuously over the floor of the hall, and people were becoming effeminate, the king bids his architect to contrive some mode by which his bedroom shall not be made a passage-way for the garreteers. To the disgust of the said chamberlain, "o' rainy nights," the builder makes an outside staircase like a ladder, and his lordship in attendance may go up, and in at the window.

Such people had but little use for a candle; they rose early, ate heartily, and slept, and no doubt snored heavily.

Scholars are scattered all along the pathway of history; but as for kings, their councilors, and the common people, they were like Scott's hero, William of Deloraine, the "stark, moss-trooping Scot," who, whatever other faults he might have had, was guiltless of violating a lady's correspondence.

> "And safer by none may thy errand be done,
> Letter or line know I never a one."

If, as Byron says, "Marmion is exactly what William of Deloraine would have been had he been able to read and write," the plentiful lack of learning was in his favor, as one had better remain a mere cattle-thief than become worse.

Lamps were known in all the ancient countries where civilization had dawned. In China, India, Egypt and Etruria, they have been so long used that the memory of man runneth not to the contrary. Comparatively modern Greece and Rome gathered them from the nations whence they derived their civilization, their mechanic arts, their conveniences, and all but their fine arts. In this latter respect, while they still retained much of the conventional, they burst the absurd fetters with which the priests had crippled the artists of Egypt. The sensuous and scoffing Greek, though a mannerist in his own way, would naturally prefer a warm model to a stone Pasht. See LAMP.

Some nations have been fortunate in the possession of bitumen, or mineral pitch, so termed, and have used it for lighting purposes from time immemorial. This has been the case especially with the Asiatic nations in the vicinity of the Caspian Sea.

Splinters of wood saturated in rock-oil, olive-oil, or animal grease, may be considered as incipient candles; and the likeness became still more apparent when a frayed piece of soft bark or a twisted lock of natural fiber, such as that of cotton or the asclepias, was dipped in melted bitumen, pitch, or an animal grease that is hard at ordinary temperatures.

The candle (*candela*) was used by the Romans before the invention of lamps (*lucernæ*). Roman candles had wicks of rush (*scirpus*), and were made of wax (*cerca*) or tallow (*sebacea*).

Alfred the Great used a graduated wax candle as a time-keeper, and placed it in a lantern to equalize its consumption by preventing flaring.

Splinters of wood saturated with animal fat were used in England by the poor, A. D. 1300. The pith of swamp-rush (*Juncus effusus*) was subsequently used for a wick, and answered the purpose tolerably, though it conducted the grease slowly, gave a very moderate light, and was easily extinguished by drafts. It is still used there, and is called a rush-light.

Diogenes (330 B. C.), who searched in daylight

with a lantern for an honest man, was anticipated by three hundred years in the prophecy of Zephaniah, wherein it is declared that Jerusalem shall be searched with candles, and the men that are settled on their lees shall be punished. The candles so frequently referred to in Scripture, generally in metaphor, were no doubt cores of twisted fibers dipped in pitch, wax, or tallow. The candlesticks in their sacred buildings were very rich and ornate, and became a regular charge for a division of the priests. It is probable light was continually maintained, as in the Magian, Egyptian, and Grecian temples.

Candles are of several varieties : —

1. *Paraffine;* obtained from the distillation of coal at a low heat, also from lignite, peat, and wood. Frequently combined in candles with sperm and stearine. See PARAFFINE.

2. *Spermaceti.* Usually of wax and spermaceti. These are molded.

3. *Composition.* Mixtures of spermaceti, tallow, with a little resin or wax, in various proportions.

4. *Stearine.* In June, 1825, Gay Lussac obtained a patent in England for candles made of the *stearic acid* of tallow, lard, or cocoanut oil.

The fatty acids are separated from the glycerine by caustic lime, the fat, lime, and water being boiled and stirred together until the mixture is fully saponified. The lime is then saturated by agitation with dilute sulphuric acid, which forms a solid sulphate of lime, and sets the fatty acids at liberty ; the latter rise to the surface, and are decanted from the limy sediment. The traces of lime are removed by washing in dilute sulphuric acid and then in clear water. The oleic acid is removed by placing the mass in bags and subjecting it to heat and pressure in a hydraulic press. The solid stearic and margaric acids are farther pressed, purified, washed while in a heated condition, decanted, and run into molds.

5. *Tallow.* These are molded or dipped.

6. *Palm-oil.* This is obtained by bruising and boiling from the fruit of the oil-palm (*Elais guineensis*). It contains about 66 per cent of a solid white fat known as *palmitine.* The oil is bleached, compressed in woolen bags. The solid matter is melted, decanted, a little wax added, and run into the molds in the frames.

7. *Wax* candles are not easily molded, and are therefore prepared by pouring wax on suspended wicks ; the cylindrical form being afterwards given by rolling hot between a wooden slab and a wet table.

Larger wax candles are made by rolling a wick into a sheet of wax, in a spiral of gradually increasing diameter. Such were those of *Drury-lane rediviva,* —

> " Tis sweet to view from half past five till six
> Our long wax candles with short cotton wicks."

Wax tapers are made by drawing a string at a regulated speed through a pan of melted wax.

The Reformation greatly decreased the consumption of wax candles and the keeping of bees. In the Castle of Wittenberg and its church 35,750 pounds of wax lights were burned yearly. In the beginning of the fourteenth century, wax and tallow candles were uncommon. Philip the Bald, Duke of Burgundy about 1361, offered to St. Antony of Vienne, for the restoration of the health of his sick son, as much wax as the latter weighed, and was held to have made a princely offer. In January, 1779, 14,000 wax candles were lighted at once in the celebration of a feast in the Electoral Palace of Dresden.

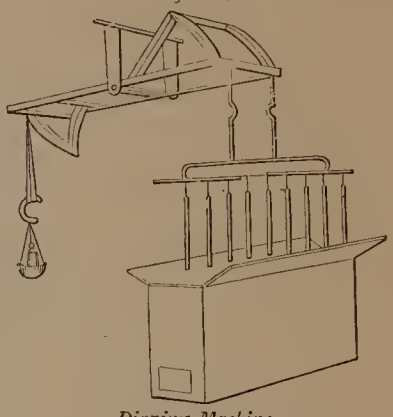
Candles which require no snuffing have slender wires twisted in with the cotton of the wick. When burning, the top of the wick turns outward in such a way as to enable the oxygen of the air to consume the charred substance, which it cannot do when in the middle of the flame.

Night-lights are short thick candles with small, thin wicks.

Machines are used for making candles with an inner core of soft or inferior material, such as tallow, and a coating of hard or superior substance, such as paraffine.

Can'dle-dip'ping Ma-chine'. A frame by which a large number of dependent wicks are dipped into a cistern of melted tallow and then lifted out of it, the process being repeated until a sufficient thickness of tallow has accumulated on the wick. The candle-dipper shown is intended to give a determinate weight to any number of candles. The wicks are suspended on rods from one end of the balance-bar, and a weight is placed in the scale at the other end. The wicks are repeatedly dipped into the tallow-vat until they acquire the desired weight.

Fig. 1057.



Dipping-Machine.

Can'dle-mold. The Sieur Le Brez of Paris is said to have been the inventor of molding candles.

The Marquis of Worcester in his "Century of Inventions," 1655, speaks of brass candle-molds in which a man may make 500 dozen in a day. He adds an ingredient to whiten, cheapen, and render the candle more lasting.

At the present day, candle-molds are usually made of pewter or tin ; in some cases glass has been employed. They may be inserted in a wooden frame, the upper part of which serves as a trough ; or several molds may be permanently attached to a tin trough, the whole constituting a single mold. Each mold consists of a cylindrical tube having a conical tip, with a circular aperture through which the doubled wick is drawn, by means of a hooked wire, allowing the loop to project a little beyond the open end of the mold ; while the other end of the wick projects beyond and closes the aperture in the conical tip. Sticks or wires are passed through the loops, their ends resting on the edges of the mold-frame. The mold is placed open end up, and the melted tallow poured into the trough by means of a ladle. When sufficiently hard, they are withdrawn by means of the wires or sticks passing through the loops.

Can'dle-stick. A well-known domestic utensil employed for holding and carrying a lighted candle, now to a great extent superseded by the introduction of gas, kerosene, etc.

The candlesticks of the ancients were very ornate, and those belonging to the temple worship were large and many-branched. The candlestick of the Hebrew Tabernacle was in the first apartment ; a constantly burning light was a feature in the worship of most Eastern nations. A candlestick or lamp-stand was emblematical of the priest's office, and was used, in metaphor at least, as an emblem of acceptable oblation ; as in Revelation, where rejection is intimated by the threat, " I will come unto thee quickly, and will remove thy candlestick out of his place, unless thou repent."

Candlesticks are mentioned in England in the reign of Edgar, A. D. 957.

Can'droy. A machine used to prepare cotton cloths for printing, spreading out the fabric as it is rolled around the lapping-roller.

Can'dy. From the Sanskrit, *'khanda.* Sugar is from Sanskrit, *'sarkara.* See SUGAR.

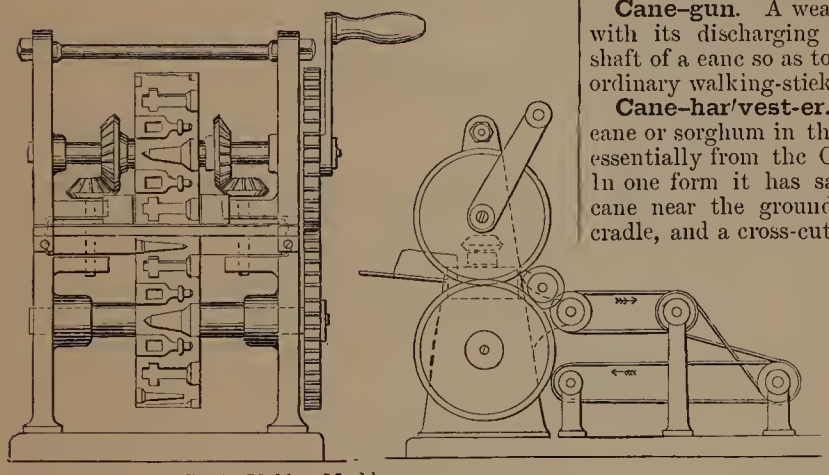
A preparation of sugar or molasses, either alone or in combination with other substances, to flavor, color, or give it the desired consistency.

Sugar-candy, as known to the British confectioner, and known as rock-candy in the United States, consists of large crystals of sugar clarified with a lesser quantity of charcoal-powder than usual, and not filtered, and the crystals aggregated on strings suspended in the vessel in which it is evaporated, and then left to cool.

Candies of various kinds, colors, flavors, and shapes, are made by different combinations of ingredients, processes, and machines, which cannot be considered at length in this work. See "The Art of Confectionary," Tilton & Co., Boston, 1866; Jarrin's "Italian Confectioner," London, 1861.

In one form of candy-making machine, the candy

Fig. 1058.



Candy-Making Machine.

in its plastic condition passes between geared rolls in which are dies or molds, and having a slight space between their outer faces; side-rolls are also employed for giving uniform speed; and the molded figures pass out on endless bands driven in opposite directions, both sides of the figures being thus set or chilled.

Cane. 1. The stem of a plant of the genus *Calamus*, very common in the South of Asia along the margins of rivers and lagoons. It is split into ribbons, and used for making chair seats and backs. Machines are adapted for splitting, planing, and polishing rattan for the various purposes to which it is adapted. After the removal of strips having the polished cuticle, the core or central portion is rounded and used for basket-making and other purposes. See RATTAN.

2. The sugar-cane (*Saccharum officinarum*). See SUGAR.

3. A walking-stick.

In the manufacture of canes great quantities and varieties of materials are consumed. The black-thorn and crab, cherry-tree and furze-bush, sapling oak and Spanish reed (*Arundo donax*), are the favorites. Then come supple-jacks and pimentoes from the West Indies, rattans and palms from Java, white and black bamboos from Singapore, and stems of the bambusa — the gigantic grass of the tropics — from Borneo. These are cut at certain seasons, freed from various appendages, assorted into sizes, and seasoned. Many different processes are required to finish even the cheapest cane. The bark is to be removed after boiling the stick in water, or to be polished after roasting it in ashes; excrescences are to be manipulated into points of beauty; handles straightened and shanks shaped; forms twisted and heads rasped; tops carved or mounted, surfaces charred and scraped, shanks smoothed or varnished, and bottoms shaped and ferruled. Malacca canes have frequently to be colored in parts, so that stained and natural surfaces are not distinguishable; ivory for handles is turned or carved into shape; horns and hoofs for handles are baked, to retain their forms; tortoise-shell raspings are conglomerated by pressure into ornamental shapes, and lithographic transfers are extensively used upon walking-sticks for the Parisian market.

The Egyptian gentleman did not consider himself "fixed" without a walking-cane. He affected a certain little horn or prong near the handle-end. The lotus-flower was a favorite knob. Their canes varied from 3½ to 6 feet long. Their names were inscribed on them in hieroglyphics.

4. A water-raising device. See HYDRAULIC CANE.

Cane-gun. A weapon comprising a gun-barrel with its discharging devices, arranged within the shaft of a cane so as to present the appearance of an ordinary walking-stick.

Cane-har'vest-er. A machine for cutting sugar-cane or sorghum in the field. It differs but little essentially from the CORN-HARVESTER (which see). In one form it has saws or blades which cut the cane near the ground, the cane falls over into a cradle, and a cross-cut saw cuts off the top, whose imperfectly matured sap injures the quality of the sugar by its feculence, and its quantity of unerystallizable sugar.

Cane-juice Bleach'er. An apparatus for decolorizing cane-juice by means of sulphurous acid vapor. As the cane is crushed, the juice from the rollers passes by a trough into a cylinder, in which is a revolving agitator consisting of a perforated cylinder with paddle-wheels. At one side of the cylinder, and communicating with it, is a tank with a perforated cover, on which a stream of water is projected. The tank communicates with an oven containing sulphur, the vapor of which escapes into the tank, where it is purified by the water, and then passes into the cylinder, where it is mingled with the cane-juice by means of the agitator.

Cane-knife. A knife like a sword or Spanish *machete*, used for cutting standing cane. It has a blade from 18 to 24 inches long, and is made in various patterns for the Southern or South American market.

The necessities of the sorghum culture in the United States have given rise to several special tools, among which are the strippers. (See CANE-STRIPPER.) These are for the purpose of removing the blades from the stalk, the former being green, immature, and absorbent, tending to depreciate the quantity and quality of the juice, which is feculent enough at any time.

The cane must be topped also, for the same reason; the saccharine juices of the top are crude and immature, and the panicle is not calculated for the purpose, its duty being to elaborate starch,

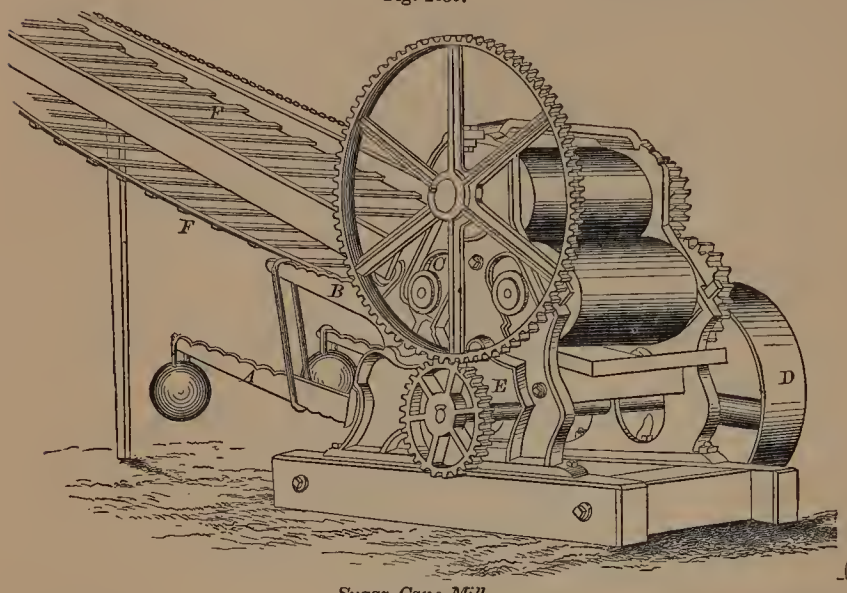
which is somewhat matured at the season of cutting.

Cane-mill. A machine for grinding sugar-cane or sorghum-stalks.

By a system of levers *A* and *B* the roll *C* is forced up against the top roll in close contact with it, so as to mash large and small canes. The strain is regulated by the shifting of the weights on the compound levers, so as to produce any pressure required. The power is applied to the pulley *D*, and transmitted to the upper roll through the pinion *E*. The endless apron *F* carries the cane to be crushed.

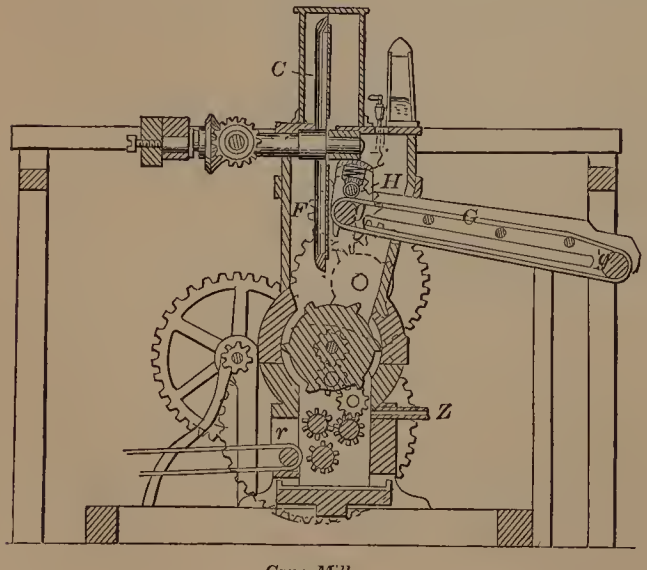
In Fig. 1060, the cane is fed into the mill by an endless belt *G*, and is held by the rollers *H g*, while the revolving knives *C F* chop it into pieces, which fall on the crushing-wheel beneath. This wheel grates the pieces against the concave and reduces them to a pulp, which then drops on the expressing-rollers, where it is subjected to a jet of steam, which is emitted by the nozzle *Z*, and the bagasse eventually carried out by the endless apron *r*.

Fig. 1059.



Sugar-Cane Mill.

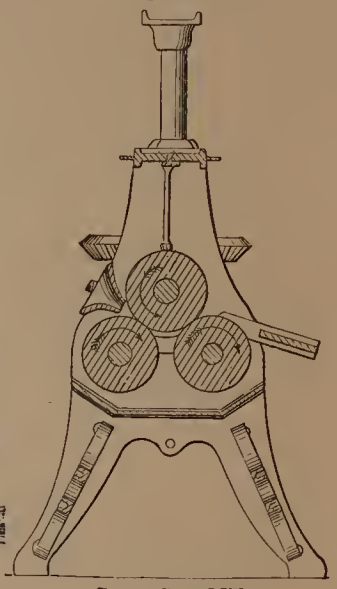
Fig. 1060.



Cane-Mill.

Fig. 1061 shows a sorghum-mill on a somewhat smaller scale, having three rolls which give two points of pressure. The cane is fed by a narrowing spout between the rolls *J K*, and then between *J L*. The juice is received in a pan, the rolls are kept clean by a scraper, and the bagasse delivered on to a discharge-board.

Fig. 1061.



Sugar-Cane Mill.

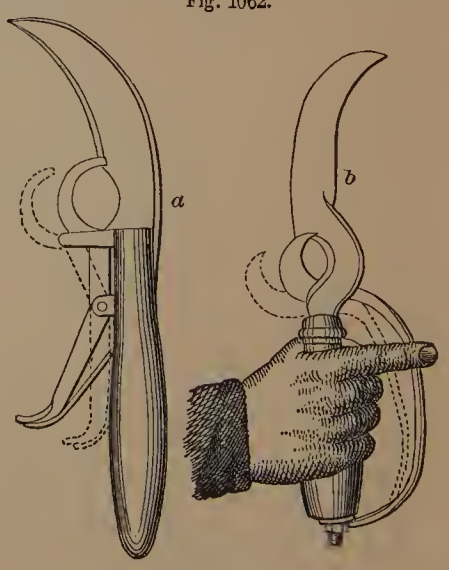
Cane-pol'ish-ing Ma-chine'. A machine for polishing the hard siliceous cuticle of rattan-splints after they are split and rived from the cane. See RATTAN; CANE-WORKING MACHINE.

Cane-press. Bessemer's cane-press has a plunger reciprocating in a trunk into which the cane is introduced transversely. A length of cane is cut off at each stroke of the plunger, and then jammed against the mass of cut cane, which is eventually driven out at the open end.

Cane-scrap'er. A machine for cutting away the woody fiber from the back of a splint of rattan, to bring it to a thin, pliable strand or braid, for weaving into a chair-seat or for similar use. See RATTAN.

Cane-split'ter. One for cutting and riving splints from *rattan*. See CANE-WORKING MACHINE; RATTAN.

Fig. 1062.



Cane-Strippers.

Cane-strip'per. A knife for stripping and topping cane-stalks.

The cane-knife and stripper *a* has a spring jaw, which coincides with an indentation in the blade, to form a circular opening. This, being clasped upon the stalk, is drawn rapidly downward, stripping off the leaves, and the blade is ready for topping when needed.

The cane may be stripped while standing in the field, which some prefer.

The cane-knife and stripper *b* has a spring jaw, which is arranged like the curved guard on a sword-hilt. The dotted lines show the position assumed by the spring jaw when opened to be placed over a stalk.

Other forms of cane-strippers are tubes armed with knives, which strip the leaves from the stalk which passes through the tube.

Cane-work'ing Ma-chine'. Machines for splitting the *strands*, *splints*, or *braids* of rattan from the central portion of the cane. The part used is the polished bark, and the machines for working it are known as *cane splitters*, *planers*, *scrapers*, *shavers*, *dressers*, *reducers*, *polishers*. Some of these names are synonymous.

Splitters make longitudinal incisions through the bark at such distances apart as may suit the circumference of the cane and the desired width of the strand. The cane is forced through an opening, which has radial knives which divide the strands, and tangential chisels which lift the strands and part it from the central core, a cone spreading the strands outward clear of the core. The next operation is to plane, pare, or shave the inner or woody side of the strand, so as to make that side quite smooth and bring the strand to an even thickness. The machine has adjustable knives and gages.

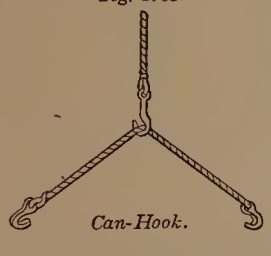
The reduced splints are then polished by passing beneath rapidly rotating wheels.

Can-frame. A cotton-roving machine in which the roving is received into *cans*. A *can-roving frame*.

Can'gan. (*Fabric.*) Chinese coarse cotton cloth. It is in pieces 6 yards long, 19 inches wide, and has a fixed currency value.

Can-hook. A device for slinging casks in hoisting. The ends of a piece of rope are reeved through the eyes of two flat hooks and stopped. The tackle is hooked to the middle of the bight.

Fig. 1033.



Can-Hook.

Can'is-ter-shot. Spherical iron shot, smaller than grape, and used with guns of all calibers up to 10 inches. They are laid in tiers in a tin case or canister somewhat smaller in diameter than the bore of the gun, having an iron plate at the top and bottom. The interstices between the shot are filled in with sawdust closely packed, and, when full, the iron cover is put down, and the end of the canister, which is cut into slips for the purpose, is turned down over it. Different-sized shot are provided for each description of cannon, those for howitzers being smaller than those for guns of the same caliber. Of the former, 48 shots are packed in the canister, and of the latter, 27. Canisters are employed against masses of troops at short ranges; at distances greater than about 400 yards, case-shot are considered more efficient. Canisters for the 12-pounder mountain-howitzer are always, and those for the smaller rifled guns generally, filled with musket-bullets.

Can-knife. A domestic implement for cutting open the lids of tin cans. See CAN-OPENER.

Can'ne-quin. (*Fabric.*) White cotton cloth from the East Indies.

Can'non. 1. A fire-arm of a size which requires it to be mounted for firing. As synonymous with *ordnance* or *artillery*, it includes great guns, howitzers, and mortars; the latter are pieces of relatively short bore and large caliber, for firing shells. Howitzers are short pieces with sub-caliber chambers, and are, in some respects, a grade between guns and mortars.

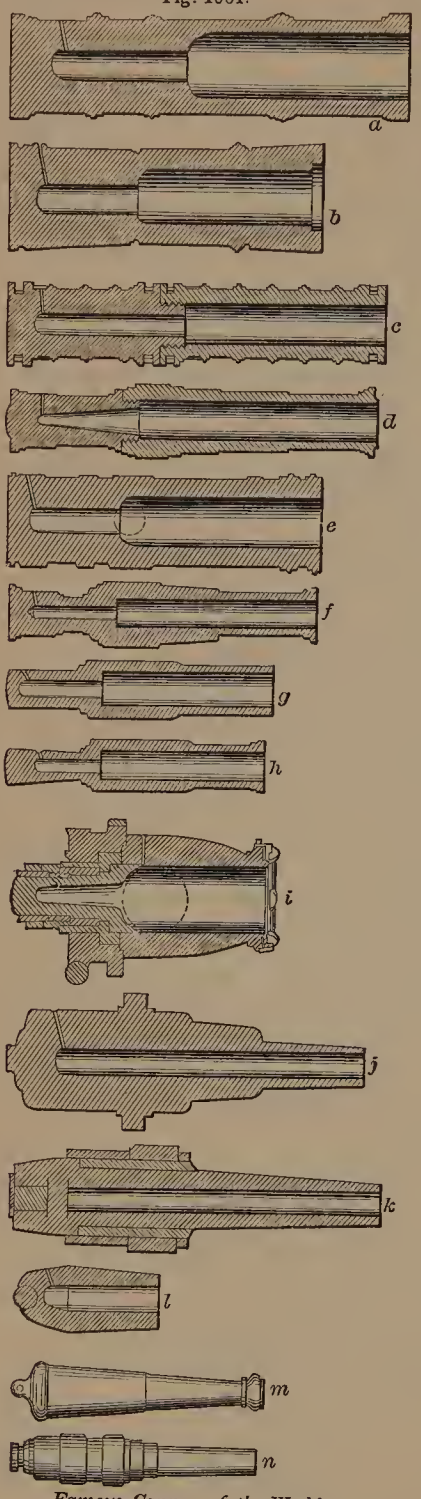
The name is derived from the same root as *canne* (Fr.), a reed; and the English words *can*, *cane*, *canal*, *canoe*, etc., which, with the German *kanne*, Latin *canna*, and Greek Κάννα, are presumably derivatives from some Sanscrit root signifying a tubular or hollow object. See HOWITZER; MORTAR.

The earliest cannon was doubtless Chinese, for thence came gunpowder. The history of cannon is the history of GUNPOWDER and of FIRE-WORKS (see under those heads). The nitrous efflorescence of the Tartar plains combined with the carbon of the argol fuel, and caused a sputtering beneath the pipkins of the nomads; curiosity and ingenuity combined the materials more intimately, and chance or care added the third ingredient, sulphur. Doubtless the paper cases and bamboos which were charged with the restless, fiery stuff were first of all intended for mere fireworks and dazzling exhibitions; but, as the art advanced, the intermittent firework was introduced, which discharged balls of fire at intervals. This appears among us as the *Roman candle*, — a very absurd name. By taking a tube of increased size, putting in a larger charge, and a missile on top of the latter, we have a fire-arm; and this may have been the condition of the matter when the advanced guard of Alexander was met in Northern India by a people who fought them with "balls of fire," as the ancient historian narrates. The word *canne*, a reed, is well chosen; for the original tube was a *reed* or *bamboo* in all probability, and was also called by that name. The thing and its title have kept well together for two or three thousand years. This sometimes happens, as in the case of two kinds of cloth well known in England, and to some extent here, *barracan* and *camlet*. Falstaff says: — "Two rogues in *barracan* (corrupted into *buckram*) set at me"; not knowing that he was talking Arabic, — *barrakân*, *barkân*, a garment of camel's hair, from *barik*, a camel. Our gossiping friend Samuel Pepys, and the more stately Sir William Temple, prided themselves on their *camlet elokes*, which, if genuine, were even then made of camel's hair, as they were in the time of Esau and Jacob. The word is about the same, strange to say, in the Aramean and Aryan tongues (Heb. *gâmâl*; Ar. *gamal*; Greek, καμήλος), which may be accounted for by supposing that the Semitics received the animal and its name from its original proprietors, the men who crossed the Hindoo Koosh, and, occupying the country of the five rivers, became trading acquaintances of the Mesopotamian nations.

Reference to the use of the fire-driven balls occurs at intervals along the pathway of history, and there is but little doubt that the Greek emperors possessed some modes of projecting fire and explosives, perhaps balls, as early as the seventh century. Condé, in his History of the Moors in Spain, speaks of them as used in the attack on fortified places as early as 1118, and at the siege of Cordova, 1280. It is reasonable to suppose that, failing to enter Europe at the Byzantine Gate, the advent would be by the Pillars of Hercules, by which route arrived cotton, paper, clocks, medicines, the present (Hindoo) system of notation, and many other things, including the

shirt, its name, uses, and materials (*chemise;* Sp. *camisa;* Ar. *kamis;* not *shirt*, which only means *short*, and has nothing to do with it). Even the Arabic *kamis* betrays the origin of the stuff, being from the Sanscrit *kschauma*, a language of a differ-

Fig. 1064.



Famous Cannon of the World.

ent family from the Arabic, the name being evidently imported from India by the Arabs along with the material; for the *trec-wool*, as Herodotus calls cotton, was known as an Indian production in the time of the "Father of History," whose credit grows brighter and brighter as years roll by, — tardy justice.

In the eleventh century, if we may credit the chronicle of Alphonso VI., written by Pedro, bishop of Leon, the vessels of the king of Tunis, in the attack on Seville, "had on board a number of iron pipes, out of which volumes of thundering fire were discharged."

In the fourteenth century the references to the uses of cannon became common. Ferdinand took Gibraltar from the Moors by cannon, in 1308. Petrarch refers to them about the same time. The English (at Crecy, 1346), the Moors, Arragonese, French, and Danes, used them during that century.

Metallic cannon were originally made by welding bars of iron longitudinally and binding them by rings, which were shrunk on over them while hot, — a plan which, with some modifications, has been revived of late years, and seems more feasible in the present state of the arts than it was 500 years ago.

Some of these ancient guns were breech-loaders, having a removable chamber, insertable in the breech, where it was wedged, for the purpose of containing the charge of powder.

The balls originally used were of stone, in some cases weighing 800 pounds or more, as is the case of the Mohammed II. gun, mentioned presently.

Fig. 1064 shows the relative sizes, and, to some extent, the mode of construction, of a number of the larger and more celebrated of the pieces of ordnance.

a is the *Tzar-Pooschka*, the great bronze gun of Moscow, cast in 1586. Bore, 122 in. long, 36 in. diameter; chamber 70 in. long, 19 in. diameter; total exterior length, 210 in.; weight, 86,240 pounds.

b, great bronze gun of Bejapoor, India, *Malik-I-Mydan*, the "Master of the Field." Cast in 1548. Bore, 28.5 in.; total length, 170.6 in.; weight, 89,600 pounds.

c, bronze cannon of Mohammed II., A. D. 1464. Bore, 25 in.; total length, 17 ft.; weight, 41,888 pounds.

d, the *Dulle-Gricte*, of Ghent, Holland. Wrought-iron, made in 1430. Bore, 25 in.; total length, 197 in.; weight, 29,120 pounds.

e, great bronze gun of Agra, India, *Dhool-Dhance*. Cast in 1628. Bore, 23.2 in.; total length, 170.2 in.; weight, 67,648 pounds.

f, wrought-iron gun, *Mons Meg*, Edinburgh. Made before 1460. Bore, 20 in.; total length, 159 in.; weight, 12,768 pounds.

g, *Michelette le Grand*, at Mont St. Michel. Wrought-iron, made in 1423. Bore, 19 inches.

h, *Michelette le Petite*, at the same place. Bore, 15 in.

i, Mallet's mortar, 1857 – 58. Bore, 36 in.; weight, 93,840 pounds.

j, English wrought-iron muzzle-loading 35-ton gun. Bore, 12 in.; weight, 48,400 pounds.

k, Krupp's breech-loading steel gun. Bore, 11 in.

l, sea-service mortar. Bore, 13 in.; weight, 11,200 pounds.

m, 68-pounder; weight, 10,740 pounds.

n, Armstrong breech-loader. Bore, 7 in.

For relative sizes of projectiles, see CANNON-BALLS.

The names adopted for cannon in the fifteenth century may be interesting: —

Name.	Weight of Ball.
Aspick	4 pounds.
Basilisk	48 pounds.
Bastard or ¾ carthoun	30 pounds.
Cannon royal or carthoun	48 pounds.
Culverin	18 pounds.
Demi-culverin	9 pounds.

Name.	Weight of Ball.
Dragon	6 pounds.
Falcon	6 pounds.
Falconet	1 to 3 pounds.
Half carthoun	24 pounds.
Moyen	10 to 12 ounces.
Rabinet	16 ounces.
Saker	5 to 8 pounds.
Serpentine	4 pounds.
Siren	60 pounds.

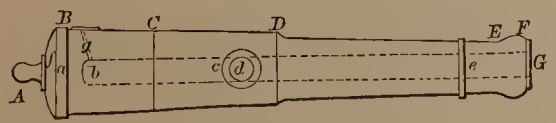
Cannon or ordnance as at present construeted, and used in Europe and America, may be divided into three classes: guns, or cannon proper, howitzers, and mortars. Carronades, which were a short, light species of cannon, intended for firing solid shot at short ranges, with small charges of powder, are now nearly obsolete. They were used on shipboard, and were principally distinguished by having no trunnions, being secured on their carriages or "slides" by a bolt passing through a lug or "navel" cast on their under side, and by a peculiar internal and external chamfer at the muzzle; the name is derived from that of the foundry on the river Carron, in Stirlingshire, Scotland, where they were originally cast.

Guns, as distinguished from howitzers or mortars, are intended for firing either solid shot, shells, or case-shot, generally at moderate elevations, and, in the case of smooth-bore guns, with comparatively high charges of powder, varying, according to the species of projectile and the object desired, to from $\frac{1}{8}$ to $\frac{1}{3}$ the weight of the solid shot proper to the caliber. The *bore* at the *muzzle* has a slight chamfer. The perpendicular portion of the muzzle is the *face*.

The different parts of a gun or howitzer are designated as follows: the *breech*, including the whole mass of metal in the rear of the bottom of the bore, and extending to the rear of the base-ring; the *cascabel*, including the base of the breech and knob; the reïnforce, or reïnforces, including the thickest part of the gun in front of the base-ring and extending forward to the *chase*, or conical part which terminates at the *neck*, or thinnest part of the gun, where the swell of the muzzle begins; or, should there be no swell, all the part in rear of the face of the muzzle is included in the chase. The *trunnions* are short journals which support the gun on its carriage, the width of which is determined by the distance between the *rimbases*.

In the accompanying section of a 32-pounder gun, from *A* to *B* is the *caseabel*, *A* being the knob of the

Fig. 1035.



32-Pounder Sea-Coast Gun.

caseabel and *f* the *base* of the *breech*; *a* is the *base-ring*; from *a* to *C* is the first, and from *C* to *D* the second *reïnforce*; from *D* to *E* is the *chase*, expanding into the *swell* of the *muzzle F*, which terminates in the *lip G*; *b* is the ellipsoidal bottom of the *bore*, indicated by the dotted lines; *c* shows the diameter and position of a *rumbase*, and *d* that of a *trunnion*. The diameter of the latter in guns is usually the same as that of the bore, and in howitzers, and mortars of the old pattern, as that of the chamber. *e* is the *chase-ring*, an ornamental fillet. The position of the *vent* is shown at *g*; its diameter is invariably two tenths of an inch. Rifled guns have a vent-piece of wrought-copper screwed into the piece.

Guns for use on ship-board have a slot in the knob of the cascabel to receive the *breeching*, a stout rope secured to ring-bolts in the side of the vessel for the purpose of checking the recoil.

Rifled cannon were first employed in actual service in Louis Napoleon's Italian campaign of 1859. General James's, 1861, were the first introduced into the United States service. These were service-pattern smooth-bores, rifled and furnished with projectiles also invented by General James. Captain Parrott's gun soon followed James's. This was constructed by shrinking a wrought-iron reïnforce over the breech of a cast-iron core, and was noted for its fewness of grooves and smallness of caliber in proportion to the weight of the projectile, which was very elongated. Wiard's gun was of steel, hammered and welded, and was accompanied by a peculiar and novel carriage. The 3-inch "Ordnance" or Griffin gun was finally adopted for rifled field-artillery, and large numbers were in service at the close of the civil war in the United States. This is a wrought-iron gun weighing about 820 pounds, rifled with 7 grooves, and carrying a projectile weighing about 10 pounds. A cast-iron rifled siege-gun, $4\frac{1}{2}$-inch caliber, and carrying a projectile weighing about 30 pounds, was introduced into the service at the same time.

About 1812, Colonel Bomford, U. S. A., introduced a chambered gun called by him the columbiad. These were made thicker at the breech and thinner at the muzzle than was then customary. This form was somewhat modified in the shell-guns of Colonel Paixhans, of the French army, about 1822, which found their way into the United States land-service at a later period under the name of sea-coast howitzers.

Experiment has gradually led to the practice of increasing the thickness of ordnance at the breech and reducing it at the muzzle, and making the resisting surfaces curvilinear. A large share of credit in this respect is due to the late Admiral Dahlgren, U. S. N.

The Rodman gun, from the late Colonel Rodman, U. S. A., resembles in general form the Dahlgren gun, but is cast with a core, through which a stream of water circulates while cooling, instead of solid, in the ordinary way; this tends to harden the metal in the immediate vicinity of the bore and increase its tenacity. This mode of casting is principally applied to the larger calibers, from 8 to 20 inches. A gun of the latter size, weighing 116,000 pounds, throws a projectile of nearly 1,100 pounds upwards of $4\frac{1}{2}$ miles at an elevation of 25°, with a maximum charge of 200 pounds powder.

The extreme length of the piece is 20 ft. 3 in.; of bore, 17 ft. 6 in.; and greatest diameter, 5 ft. 4 in.

The Crimean war (1854) imparted quite an impulse to the improvement of ordnance and projectiles.

Lancaster's, one of the first of these, obviated rifling by making the bore elliptical, but with a gradual twist throughout, so that a projectile of corresponding shape would receive a rotary motion during its passage through the bore.

Armstrong's first gun was made in 1855, and a patent obtained in 1857. It has been extensively adopted in the British service. It is built up of layers of wrought-iron bars twisted spirally in reverse directions over a steel core, and bound together by one or more wrought-iron rings shrunk on at a white heat. A peculiar breech-loading mechanism is also used with this gun. See ARMSTRONG GUN.

In the Ames cannon, a series of compound longitudinal rings are consecutively welded to a concave breech-piece, upon a removable mandrel.

Blakeley's cannon is composed of an inner tube, which may be of *mild* steel, upon which an outer tube of less extensible material, as hard steel, is shrunk. His first English patent was in 1855. The American patent, in which the process here mentioned is described, bears date 1864.

Whitworth commenced experimenting about 1855, and his guns underwent a satisfactory test in 1860. The leading peculiarities are a bore which is hexagonal in cross section without grooves, and having a rapid twist; the projectile is a hexagonal bolt whose spiral conforms to the twist of the bore and is destitute of knobs and used without a sabot. The device for breech-loading differs from that of Armstrong.

Krupp's first steel cannon (1849) were objected to on account of their novelty and expense. He has since furnished cannon to Asia as well as Europe. He has used a mixture of steel and iron, the latter metal increasing the elasticity.

The compound was cast in plumbago crucibles, and forged while still at a red heat under an enormous steam-hammer, compressing the mass two or three per cent, and nearly doubling its tensile strength. Cannon of over 8-inch bore are made up of several concentric rings; those of a smaller size are forged solid.

Krupp's monster gun, at the Paris Exposition of 1867 (see illustration on opposite page), consists of an inner tube weighing 20 tons, upon which are shrunk cast-steel rings, forming at the breech a threefold and at the muzzle a twofold layer of metal; these are made from massive ingots without welding, weighing together 30 tons.

The total weight of the gun is 50 tons; caliber, 14 in.; total length, 17½ ft.; weight of solid shot, 1,212 pounds; weight of shell, 1,080 pounds; charge of powder, from 110 to 130 pounds. A special car weighing 24 tons was constructed for the transportation of this gun to Paris.

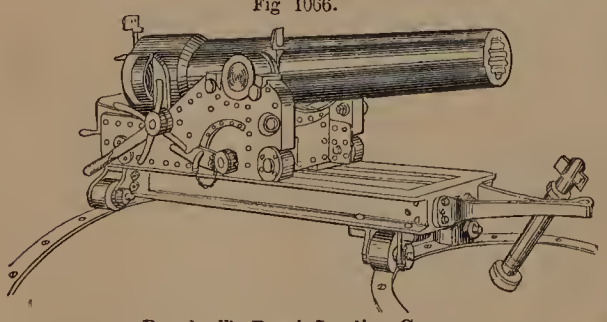
The gun is mounted on a steel carriage weighing 15 tons, supported on a center-pintle chassis weighing 25 tons.

The breech-loading is on Krupp's patent plan. The shot or shell is raised by a block and fall, and is rolled into the side of the breech through an aperture closed by a slide.

Though many breech-loading guns of this or similar construction were employed by North Germany during the late Franco-Prussian war, we know of none at all approaching it in size.

Baron Wahrendorff, of Sweden, some 30 to 40

Fig 1066.

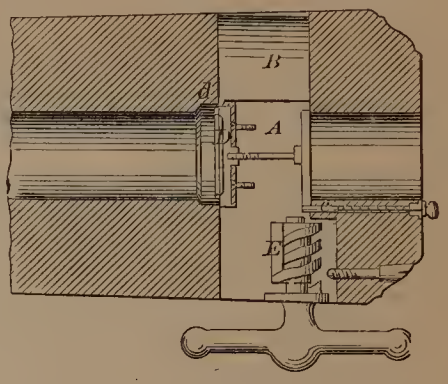


Broadwell's Breech-Loading Gun.

years ago, contrived a breech-loading cannon, in which the bore extended the whole length of the piece, the projectile being passed in at the rear and secured by a transverse breech plug and wedge. Caralli's rifled cannon of later date loaded at the breech in a nearly similar way.

The Broadwell breech-loading cannon has a steel wedge or breech-block *A*, moving horizontally in a mortise *B*, made through the breech of the piece at right angles with the bore. This breech-block is

Fig 1067.



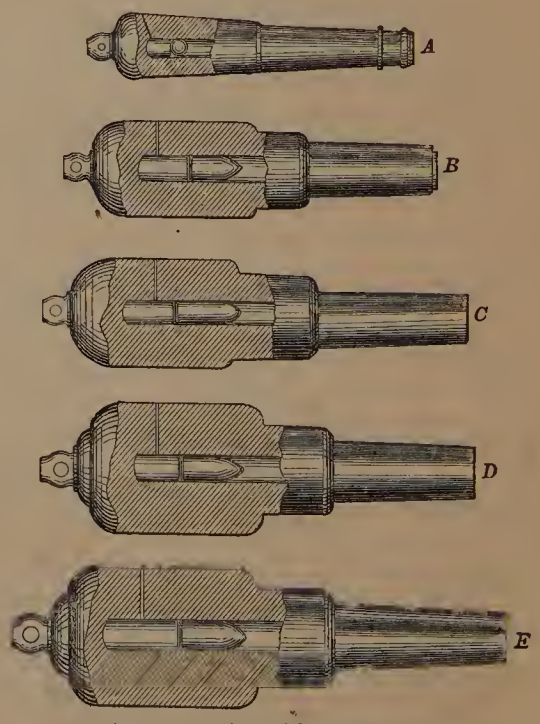
Broadwell's Breech-Block (Detail View).

operated by means of a partially threaded screw, *E*, located in its rear side, which finds its socket-thread in the gun behind it, and is thus locked in position at the moment of fire.

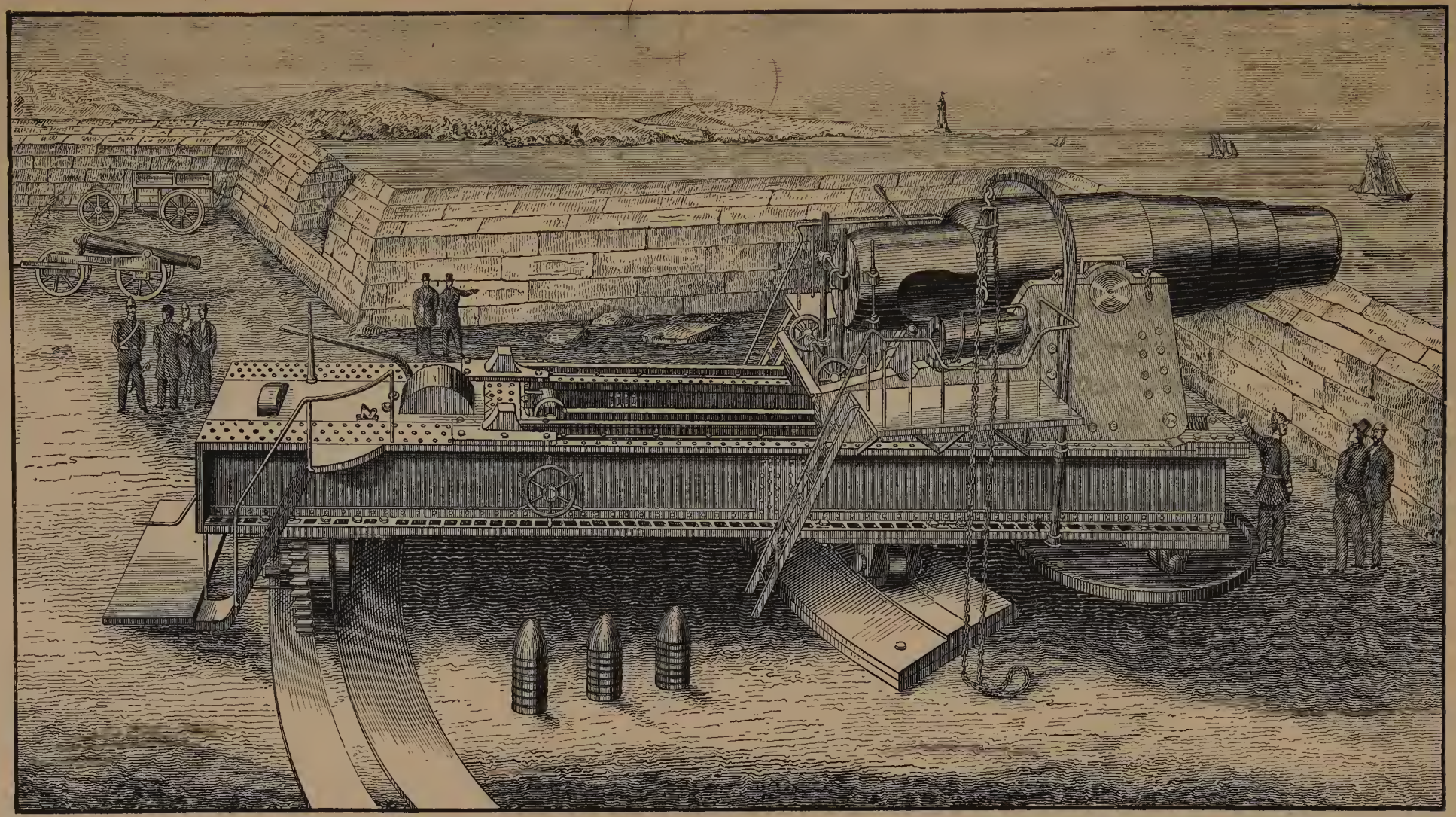
One half-turn of this screw is sufficient to loosen the block, and permit it to be easily withdrawn to the position for loading the piece.

The gas-check consists in a peculiarly curved steel ring *d*, located in a correspondingly shaped chamber in the bore of the gun immediately in front of the breech-block. When the charge is fired, this ring is expanded by the gases and pressed tightly against the walls of its chamber and also against a steel bearing plate, *D*, let into the face of the breech-block, thus forming a perfectly tight gas-check.

Fig. 1068



Armaments of English Iron-Clads.



KRUPP'S 1200-POUNDER BREECH-LOADING RIFLED GUN.

PLATE VIII.

See page 448.

The armaments of the British iron-clads are of heavier and heavier guns as years go by. The annexed figure gives a comparison of the relative proportions and weights of the guns: *A*, "Warrior's" armament, — 68-pounder; 4¾-ton gun. charge, 16 pounds. *B*, "Bellerophon's" armament, — 250-pounder; 12-ton gun; charge, 43 pounds. *C*, "Hercules's" armament, — 400-pounder; 18-ton gun; charge, 60 pounds. *D*, "Monarch's" armament, — 600-pounder; 25-ton gun; charge, 70 pounds. *E*, "Thunderer's" armament, — 600-pounder; 30-ton gun; charge, 100 pounds.

These figures are exceeded by the latest English gun (the 35-ton), which is by no means, however, what it is paraded as being, — the largest gun in the world.

	Pounds.
Woolwich, 35 tons 7 cwt. (English count) =	79,084
Armstrong (Big Will)	50,400
Krupp, 14-inch (1,080-pounder) . .	100,000
Rodman, smooth-bore (20-inch) . .	116,497

The "Thunderer," 4,400 tons, and the "Fury," 5,000 tons burden, are designed each to carry four of these 35-ton guns, in two turrets, two guns being placed in a turret side by side.

Among the earliest cannon made in Europe were *breech-loaders*, specimens of which are preserved in the Artillery Museum of Woolwich, England.

The charge was inserted in an iron cylinder, which was fixed by wedges in its place in the breech of the gun.

Breech-loading cannon were introduced by Daniel Spekle, who died in 1589, and by Uffanus.

Cannon of ice were made at St. Petersburg in 1740, and repeatedly fired, — a whim.

All the rifled cannon in the British service of less than 6.3-inch caliber are breech-loaders.

At the siege of Badajoz, the firing was continued for 104 hours, and the number of rounds fired from each 24-pounder iron gun averaged 1,249; at the siege of St. Sebastian each piece was fired about 350 times in 15½ hours. But few of these pieces were rendered unserviceable; but it is estimated that three times the number of brass guns would have been required to produce the same effect, or maintain such long and rapid firing.

An experimental Armstrong 32-pounder, weighing 26 cwt., with a charge of 6 pounds and an elevation of 33°, sent its projectile 9,153 yards. The range was carefully measured. Mr. Whitworth states that his little 3-pounder, fired at Southport, attained a range of 9,688 yards. The long experimental 7-inch gun of six tons, designed by Mr. Lynall Thomas, with 25 pounds of powder, propelling a shot of 175 pounds, and fired with an elevation of 37½°, ranged 10,075 yards. There have been several other instances of long ranges, and there would be more but for the general uselessness of firing at distances where no aim can possibly be taken.

The accelerating principle has been again and again suggested, and consists in increasing the velocity of the projectile by the ignition of successive charges of powder during the passage of the ball through the bore. Henry Bessemer, and Captain Fitzmaurice of the British navy, are yet inventing and confident. The former designs a tube 60 feet long, with charges 60 in number, fired by electricity in quick succession, so that each may exert its force before the ball escapes at the muzzle.

Moncreiff's plan for mounting ordnance is to make the recoil of the gun in firing swing the gun backward and downward, so as to depress it below the sill of the embrasure and allow the gunners to load it without exposure to the enemy.

Various modes of mounting and operating guns have been devised for monitor and turret use, for which consult patents of Eads and Ericsson. Very ingenious indeed are many of these devices.

2. (*Machinery.*) A metallic hub or sleeve, fitted to revolve on a shaft or with it.

Can'non-ball. Properly speaking, this term should only be applied to spherical solid projectiles; but it appears to have become generic, extending to elongated bullets for rifled guns, and even to hollow projectiles.

Technically, balls are termed solid shot, or simply shot, to distinguish them from hollow projectiles. They are now universally made of cast-iron, though stone was formerly employed, and was used in some instances by the Turks as late as 1827.

In South America balls of copper were formerly used, this metal being there, at that period, cheaper than iron.

The *Fœdera* mentions an order of Henry V., A. D. 1418, to the clerk of the works of his ordnance, for making 7,000 stone balls for his cannon, of different sizes, from the quarries of Maidstone, in Kent. Although *iron* balls are noticed as being used by the French towards the close of the 14th century, yet no mention is made of them in English history before 1550, when, in an acquittance for delivering up the artillery at Boulogne, they are styled *bouletz de fer*. Stone balls were not entirely laid aside in England till the civil war, time of Charles I.

Elongated bullets for rifled cannon are now frequently, especially by English writers, termed "bolts." These are often made flat-pointed or angularly pointed, to more readily penetrate iron plating. (See *m*, Fig. 1069).

Shells are hollow projectiles in which is placed a quantity of powder sufficient to burst them when exploded by means of a fuse. See FUSE; SHELL.

Case-shot are thinner than shells, adapting them to contain a number of bullets, which are scattered at the moment of bursting.

All projectiles are made smaller than the bore of the gun which they are intended to fit. The difference between their diameter and that of the bore of the gun is termed the *windage*. This is much less for rifled than for smooth-bore arms, the former in some cases amounting to .15, and the latter usually to .025 of an inch.

Of the class adapted for rifled guns, those most prominent during the late civil war in this country were the Parrott, Hotchkiss, and Shenkl. See SHELL.

Projectiles for rifled cannon may be given a rotary motion by the expansion of a soft metallic sabot at the rear, or by means of studs cast on or affixed to the shell. The former by their expansion at the moment of firing fill the grooves, while the latter are necessarily compelled to follow the grooves, being unable to leave them without being torn away.

Fig. 1069 shows a few of the numerous kinds of cannon-projectiles which have been devised.

a, the "Hotchkiss." At the moment of firing, the wedge-shaped piece, shown in section, is driven forward, expanding a soft metal ring which fills the grooves.

b b, the "James." The gas passes through the aperture at the back, driving out a number of pins, which expand a fibrous mass surrounding the shot and encircled by a metallic ring, which is thus forced to enter the grooves. In the second this is effected without the aid of pins.

c c are vertical and longitudinal sections of a similar projectile having a detachable point.

d, "Read." The gas enters through holes around the base, and expands an encircling band.

e, "Shalcr." Driving forward the metallic cup at the base flattens it and expands the sabot.

f, "Cochran." A band of copper wire is expanded by forcing forward a cup at the base of the projectile, against a cylinder which surrounds the latter.

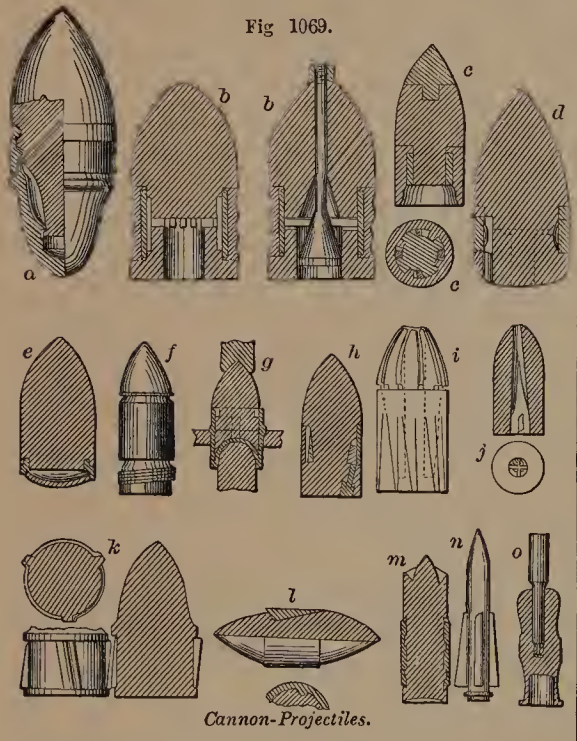
g, "Boekel." The illustration shows the annular soft-metal packing being attached to a projectile by a swage and dies while the point is held on an anvil.

h, "Atwater." The packing of wire webbing or cloth is expanded by wedges driven forward by plungers at the base of the shot.

i, "Woodbury," a spirally grooved projectile, with a sabot similarly grooved, for firing from a smooth-bore gun.

j, "Taggart," has a spirally flanged central aperture intended to cause the bullet to rotate on its

Fig 1069.



Cannon-Projectiles.

axis by atmospheric action when fired from a smooth-bore gun.

k, "Sigourney," has projecting spiral ribs to take the grooves and impart rotary motion, and annular belts which fit the lands and direct the flight.

l, the "Currie" ball, conoidal at each end, and having an annular groove deepening from front to rear, into which is cast a soft-metal packing-ring.

m, a "bolt" with chisel-edged points for cutting through iron plating. The annular groove between the cutting-edges and the point is filled with soft metal, to prevent retardation of the flight.

n, an clongated bullet with spiral flanges for imparting rotary motion when fired from a smooth-bore gun. It will be obvious to practical men that some of the last projectiles figured would be of littlc service.

o, an "accelerating" projectile. This bullet has in front a plunger, which, on striking an object, explodes, by percussion, a charge contained in a chamber, giving a new impetus to the projectile.

For varieties of cannon-shot, see under the following heads: —

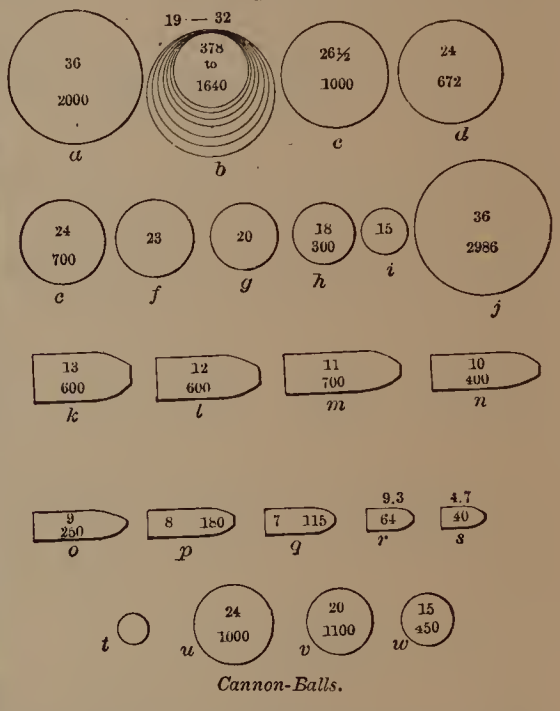
Angel-shot.
Bar-shot.
Bolt.
Bomb.
Burrel.
Canister.
Carcass.
Case-shot.
Chain-shot.
Cross-bar shot.
Double-headed shot.
Grape-shot.
Langrel.
Nail-shot.
Round shot.
Sand-shot.
Segment-shell.
Shell.
Shrapnel.
Spherical case-shot.
Sub-caliber shot.
Tier-shot.
Trundle-shot.

See also PROJECTILES, for list of other missiles impelled by discharge from cannon.

See also WEAPONS.

Fig. 1070 gives an idea of the proportionate magnitudes of some of the projectiles of celebrated can-

Fig. 1070.



Cannon-Balls.

non. The diameters and weights are inscribed in figures; the upper figure being the bore, the lower figure the weight, of the shot. (The balls *a t i*, in the figure, are of stone.)

For description of the cannon themselves, see CANNON.

In Fig. 1070, *a* is the stone projectile of *Tsar-Pooschka* (Muscovite).

b shows seven sizes of the Turkish granite balls of Scutari, weighing respectively 373, 498, 747, 810, 871, 1,182, and 1,640 pounds.

c is the basalt ball of *Malèk-y-mydan* (Indian).

d is the granite ball of the great gun of Mohammed II.

e, the stone ball of *Dulle-Griete* (Flemish).

f, stone ball of *Dhool-Dhance* (East Indian).

g, stone ball of *Mons Meg* (Scotch).

h, granite ball of *Michelette le Grand.*

i, granite ball of *Michelette le Petite.*

j, Mallet's iron bomb (English).

k to *s*, English elongated iron projectiles.

t, 68-pound ball (1841).

u, Liege, French, 1,000-pound ball (1832).

v, "Beelzebub" and "Puritan," American, 1,100-pound ball (1866).

w, Rodman, American, 450-pound ball (1866).

Can'non-cast'ing. The molds for brass cannon are formed by wrapping a long taper rod of wood with a peculiar soft rope, over which is applied a coating of loam, which, as the work proceeds, is dried over a long fire, a templet being applied to form the proper outline. This model is made about one third longer than the gun is to be. It is next, when dry, blackwashed, and covered with a shell of loam not less than three inches thick, secured by iron bands, which is also carefully dried. The model is next removed by withdrawing the taper rod and the rope, and extracting the pieces of loam. The parts for the cascabel and trunnions are formed upon wooden models, and then attached to the exterior of the shell; handles, dolphins, or ornamental figures, are modeled in wax, and placed on the clay model previous to molding the shell, from which they are melted out before casting.

When dry, the shells are placed muzzle upward in a pit in front of the furnace or furnaces, and the earth thrown in and well rammed around them. At the same time, a vertical runner, which enters the mold near the bottom, or not higher than the trunnions, is made for each mold, terminating in a trough or gutter, at the far end of which is a square hole to receive any excess of metal. The runners are stopped by iron bars, which are successively withdrawn as the preceding mold in order becomes filled, and the furnace or furnaces are tapped by an iron bar with a taper end, so as to regulate the flow of metal, by making a larger or smaller orifice, as required. A spade or gate across the gutter at a certain point prevents the metal from flowing beyond this till the molds towards that end are filled, and when the last is removed the metal is allowed to flow into the square pit before referred to.

The general process with iron cannon is very similar. In all such large castings a large head or sprue must be allowed to maintain a pressure adequate to produce a sufficient solidification at the breech, where the metal should be strongest.

In casting the first 20-inch gun at Fort Pitt Foundry, in 1864, the mold was in four pieces; the core was on the Rodman plan, a fluted cylinder of cast-iron, circular or semi-elliptical at the lower end, and closed at top by a cap through which a pipe enters, conducting water to the bottom, from which it rises to near the top, and is carried off by a waste-pipe.

Five furnaces, charged in all with 105 tons of metal, were employed, — two containing 23 tons, one 39, and the two smaller between 5 and 10 tons each. The molten metal was admitted to the bottom of the mold through two gates, one on each side. Six hours were required for its complete fusion, which was maintained for one hour twenty-four minutes, when the large furnaces were tapped, filling the mold in twenty-two minutes. So long as a constant flow of water was admitted to the core, the temperature of that issuing from the discharge-pipe did not exceed 92° F., falling within twenty-one hours to 57°; but when the flow was stopped, the temperature rose to the boiling-point. (See page 447.)

Can'non-clock. A cannon with a burning-glass over the vent, so as to fire the priming when the sun reaches the meridian. Such pieces were placed in the Palais Royal and in the Luxembourg, at Paris.

Can'non-lock. A contrivance placed over the touch-hole of a cannon to explode the charge.

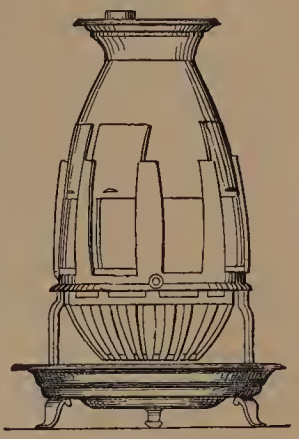
Can'non-met'al. An alloy of copper and tin. See GUN-METAL; ALLOY.

Can'non-pin'ion. (*Horology.*) A squared tubular piece, placed on the arbor of the center-wheel, and adapted to hold the minute-hand.

Can'non-roy'al. An old grade of service-cannon, 8½ inches bore, 66-pounder. A *carthoun.*

Can'non-stove. A cast-iron stove, somewhat cannon-shaped, the lower portion, or bosh, forming the fire-pot and the upper a radiating surface. It has no flues proper, but the stove-pipe stands upon the top, encircling the thimble. The door is above the level of the usual level of the coals, and the middle zone of the stove may have, as in the example, doors and panes of mica.

Fig. 1071.



Cannon-Stove.

Ca-nu'la. (*Surgical.*) A small tube introduced by means of a *stilette* into a cavity or tumor, to withdraw a fluid.

Ca-noe'. A light boat, narrow in the beam and adapted to be paddled.

The *coracle* of the ancient Britons was a frame of willow covered with hides. The North American Indian made his canoe of cedar-wood covered with an unbroken sheet of the bark of the white birch. The Indians of the plains used buffalo-hide. In the wooded regions devoid of birch the canoe was a shaped and hollowed log.

The Rob Roy canoe, so celebrated from the adventures of Mr. Macgregor in traveling 3,000 miles on the navigable streams and head-waters of Europe and Asia, was made of well-seasoned and selected plank. Such a canoe is 13 feet long, 26 inches wide, 12 inches deep, and has a "comber" of 2 inches. The opening in the deck in which the voyager places himself is 4 feet long and 1 foot 8 inches wide. A canoe for two persons, sitting face to face, should be about two thirds larger.

In New York, the form and construction known as the nautilus is most approved, it is made of wood, the keel being oak and the hull of cedar. Abroad, there are several types, all more or less in favor. Assuming the traveler to weigh one hundred and sixty pounds, a nautilus should have a length of 14 feet, and a beam of 2 feet 4 inches. It is lowest amidships, its depth there being 12 inches, rising to 20 at the stern and 22 at the bow. In each end is a water-tight compartment, and the whole is so contrived that in event of a capsize it will right itself as soon as relieved of its burden. It is fitted with a sprit-sail, 7 feet from tip to boom, and is, indeed, calculated more for sailing than paddling, while the reverse is the case with most of the English canoes.

Appliances and means are carried for cooking, fishing, hunting, etc.; and in supplying these minor conveniences much ingenuity and adaptiveness has been displayed. An apparatus heated by a spirit-lamp serves for the preparation of food. Waterproof haversacks carry tea, coffee, sugar, rice, and other comestibles, as well as quinine to cure the ague, which pursues bipeds without feathers who paddle about in wet places.

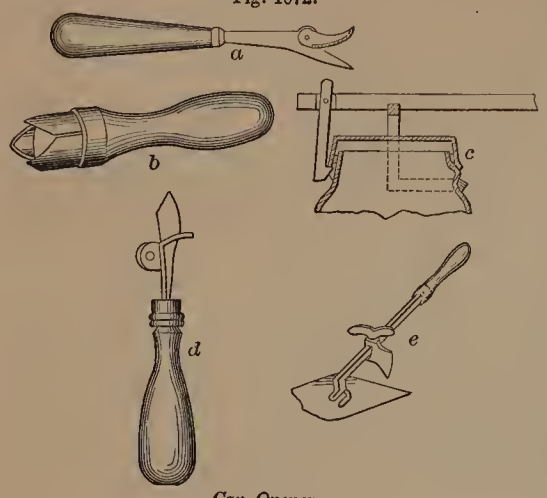
Canoes are also made of galvanized iron, caoutchouc, and paper. The latter comes the nearest in lightness to Hiawatha's: —

> "Thus the Birch Canoe was builded
> In the valley, by the river,
> In the bosom of the forest;

And the forest's life was in it,
All its mystery and its magic,
All the lightness of the birch-tree,
All the toughness of the cedar,
All the larch's supple sinews;
And it floated on the river
Like a yellow leaf in autumn,
Like a yellow water-lily."

The canoes of the Feejees are double, of unequal size; the smaller serving as an outrigger. Large ones are 100 feet in length. The two canoes are

Fig. 1072.



Can-Opener.

connected by a platform about 15 feet wide, and projecting two or three feet beyond the sides. The bottom of each consists of a single plank; the sides are fitted by dovetailing, and closely united by lashings passed through flanges left on each of the pieces. The joints are closed by the gum of the bread-fruit tree. The sails are large, and made of mats. The mast is about half the length of the canoe, and the yard and boom are still longer. Captain Cook estimated the naval force of the Society Islands at 1,700 war-canoes, manned by 68,000 men. See BOAT, pp. 311, 312.

Can'on. 1. (*Surgical.*) An instrument used in sewing up wounds.

2. (*Printing.*) A large type, used for posters and handbills.

3. The part of a bell by which it is suspended. Otherwise called the *ear*.

Can'on-bit. The barrel of a bit; the portion in the mouth of a horse.

Can-o'pen-er. A domestic implement for opening cans containing fruit, oysters, and what not. The illustration shows several forms.

a has a prong which is thrust through the tin and forms a fulcrum for the cutter.

b is designed to bore a round hole.

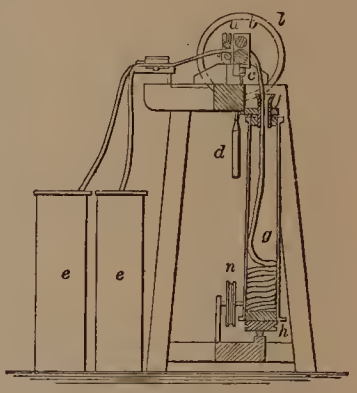
c is a lever-arrangement to pry up the lid of a can which is held down by the pressure of the atmosphere.

d e, like *a*, have points which form fulcrums or centers of oscillation for the cutters.

Can'o-py. (*Architecture.*) A covering or hood, the enriched projecting head to a niche or tabernacle. The tablet or drip-stone, whether straight or circular, over the heads of doors or windows, if enriched, is so called.

Can-rov'ing Ma-chine'. (*Cotton-manufacture.*) In this machine the slivers from the cans *e e* are drawn through the rollers *a b c*, the proper pressure being maintained by a weight *d*, and the consolidated slivers delivered into the can *g*, fixed to a pivot at the bottom, and supported at the neck *f*, while it is made to revolve by a strap passing round the pulleys *n* and *h*. This rotary motion gives the sliver a slight twist, which constitutes it a roving, as it passes in, and coils it up in the can in a regular manner.

Fig. 1073.

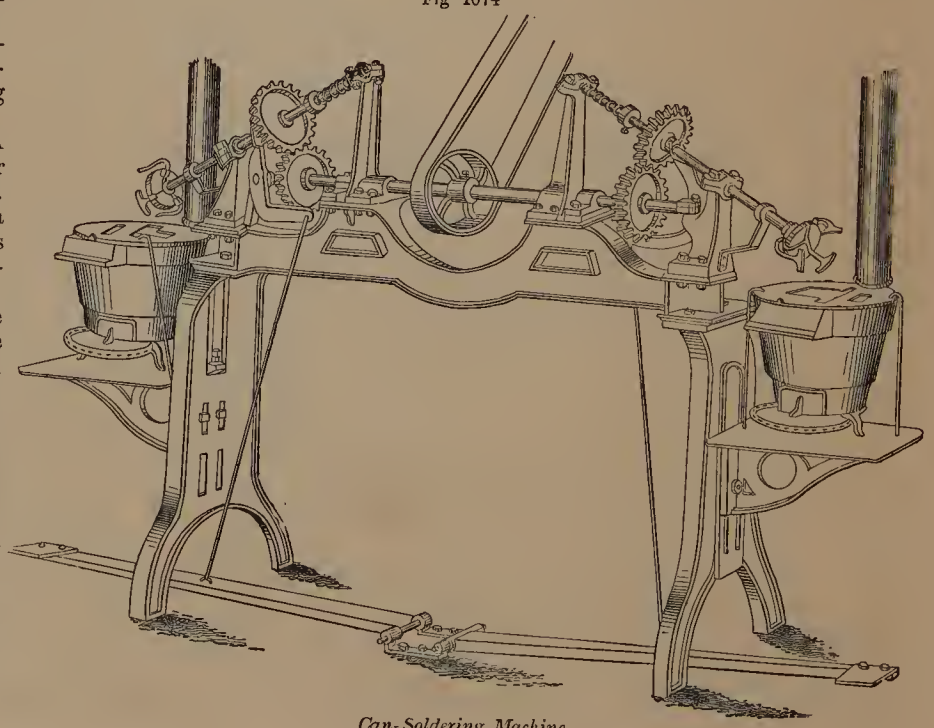


Can-Roving Machine.

When the can is full, it is opened, the *roving* taken out and transported to a roving-machine, where it is wound upon reels ready for spinning.

Can-sol'der-ing Ma-chine'. In this apparatus a clutch on the end of a shaft having a bevel-wheel gearing, with the bevel-wheels turned by the central pulley, is placed at either end of the frame, enabling two workmen to operate at once. Beneath each clutch is a bracket for receiving a soldering-furnace. A can, with its bottom or top inserted, is

Fig 1074



Can-Soldering Machine.

fixed upon the clutch, the treadle being depressed to throw the bevels out of gear, and withdraw the clutch from the surface of the metal in the soldering-furnaces; releasing the treadle, the bevels are thrown into gear, and a spring forces the rod bearing the clutch downward, until the lower edge of the can is slightly immersed in the molten solder, and caused to rotate against the surface of a soldering-iron held therein, after which the treadle is again depressed and the can removed.

Cant. An angle; a bevel; a chamfer; a slope; an arris; a hip; a ridge.

1. (*Building.*) *a.* A *canted* wall is one which forms an angle with the face of another wall.

b. A *canted* column is one whose flutes are formed in cants instead of curves.

c. When the angles are removed or absent from a post, beam, or pillar, it is said to be *canted.*

d. A *canted* molding is one which has angular turns, but no quirks or circular work. See MOLDING.

2. (*Coopering.*) One of the segments forming a side piece in the head of a cask.

3. (*Nautical.*) A piece of wood laid upon the deck of a vessel, to support the *bulkheads.*

4. (*Shipbuilding.*) A *cant-timber* or *cant-frame* is one which is not square with the keel; less than 90°.

5. The angle, as of the head of a bolt. A bolt with a hexagonal or octagonal head is said to be six or eight *canted.*

6. (*Gearing.*) A segment of the rim of a wooden cog-wheel.

Can'ta-lon'. (*Fabric.*) A species of woolen stuff.

Cant-block. (*Nautical.*) A large block used in canting whales; that is, turning them over in flensing. The *cant*-purchase is suspended from the main-mast head.

Cant-board. A division in the conveyer-box of a flour-bolt, to separate grades of flour or offal.

Cant-chis'el. A long and strong chisel with the basil and a rib on one side.

Cant'ed. A term applied to an object when a corner is chamfered off, — not rounded off, but presenting angles. See CANT.

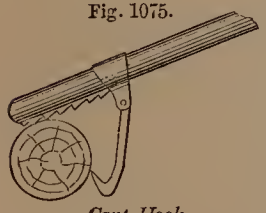
Cant-fall. (*Nautical.*) The purchase used in turning over the carcass of a whale when *flensing.*

Cant-file. A file having the shape of an obtuse-angled triangle in its transverse section; used in filing the inner angles of spanners and wrenches for bolts with hexagonal and octagonal heads.

Kant is an edge or corner in many of the old dialects of Europe, and the Greek κανθός, the corner of the eye, has an allied signification.

Cant-hook. A lever and suspended hook adapted for turning logs in the yard, on the skids, or on the saw-mill carriage.

Fig. 1075.



Cant-Hook.

Also, a sling with hooks for raising and tilting casks, to empty them.

Can'tick-quoin. (*Nautical.*) A triangular block of wood, used in chocking a cask, to keep it from rolling when stowed.

Can'ti-lev'er. One of a series of timbers, of the nature of consoles, projecting from the face of a wall to sustain an eave, cornice, entablature, or balcony. A *modillion.*

Cant'ing-wheel. A star-wheel for an endless chain. The cogs are canted; that is, the corners cut off. See STAR-WHEEL.

Can'tle. (*Saddlery.*) The upwardly projecting portion at the rear part of a saddle. See POMMEL.

Cant'ling. (*Brick-making.*) The lower of two courses of burned brick which inclose a brick-clamp.

Cant-mold'ing. One neither perpendicular to the horizon, nor to the plane of the object to which it is attached.

Can'ton. (*Building.*) A salient corner formed of a pilaster or quoins, which project beyond the general faces of the walls.

Can'ton-flan'nel. (*Fabric.*) Cotton cloth upon which a nap is raised in imitation of wool.

Can-toon'. (*Fabric.*) A strong cotton goods, with a corded surface on one side and a satiny finish on the other.

Cant-timber. (*Shipbuilding*). One of the timbers at the end of a ship which are *canted*, that is, rise obliquely from the keel. The forward pair of *cant-timbers* are called the *knightheads*, and form a bed for the reception of the bowsprit. The cant-timbers towards the stem incline forward; those towards the stern incline aft.

A *cant* is an angle, and the timbers in the narrow interior angles at the stem and stern are called *cant-timbers.*

The timber at the extreme angle is built in solid, and is called the *dead-wood.*

Can'vas. (*Fabric.*) From *cannabis*, hemp. An unbleached, heavy cloth of hemp or flax, used for sails, tents, backing for pictures, bed-bottoms, and for other purposes where a fabric of great stability is required.

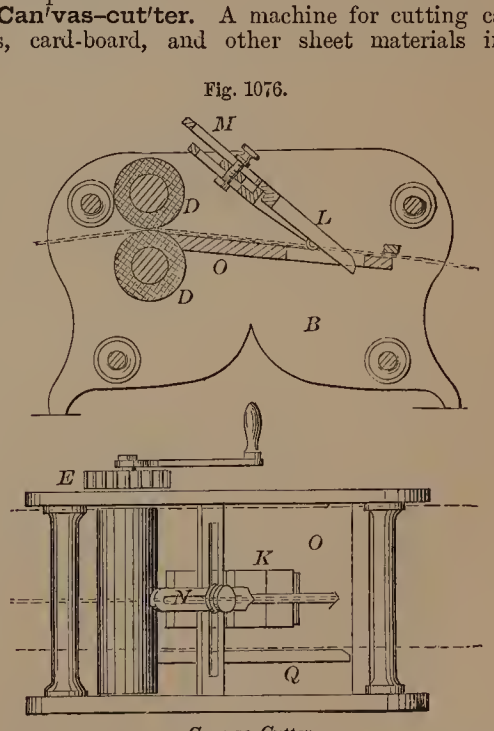
An open variety is used for tambour and worsted work.

Canvas for sails is made from 18 to 24 inches wide, and numbered from 0 to 8, No. 0 being the thickest. A bolt is from 39 to 40 yards long. The best is made of long-fibred flax.

Bolts of canvas weigh from 25 to 48 pounds, and strips 1 inch wide have a tenacity varying from 200 to 480 pounds.

Can'vas-cut'ter. A machine for cutting canvas, card-board, and other sheet materials into

Fig. 1076.



Canvas-Cutter.

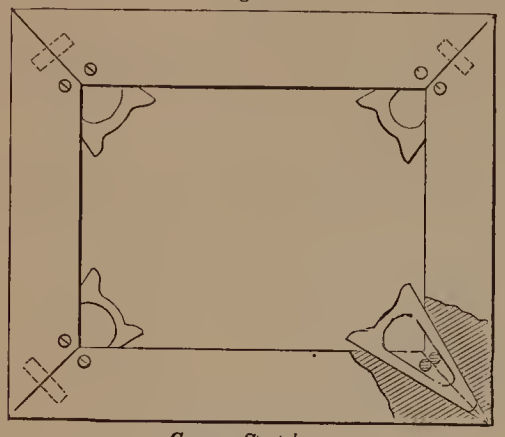
strips; the stuff is fed between rollers *D D*, guided by a strip *Q*, and slit by a knife *L*, which is ad-

justed to such distance from the latter as may be desired.

Can'vas-frame. (*Calico-printing.*) A diaphragm of canvas in a paint-vat used in a certain process of calico-printing. The color is admitted by a stop-cock below, and up to the level of the canvas.

Can'vas-stretch'er. A quadrilateral frame on which canvas is extended for painters' uses. In the

Fig. 1077.



Canvas-Stretcher.

one shown, the miter-joints have dowel-pins, and are expanded by the wedges, the pins in the open center of the latter preventing their falling out.

Caout'chouc. Commonly called gum-elastic or india-rubber. A substance derived from the sap of various trees, of which the *Jatropha elastica*, called by the natives *hevee*, flourishing in the plains of Brazil, toward the lower part of the Amazon River, is the principal source of production. It was first brought to Europe in the early part of the eighteenth century, and fifty years later was mentioned by Dr. Priestly as a substance excellently adapted for removing pencil-marks from paper. Crumb of bread had previously been employed for this purpose.

The sap, obtained by tapping the trees, is dried over a fire, which gives it the dark appearance observable in the rubber of commerce. For many years its various adaptabilities seemed unperceived, but in 1791 Samuel Peal obtained a patent for water-proofing fabrics by means of this gum dissolved in spirits of turpentine; though this does not seem to have led to any practical results. Besides turpentine, ether, bisulphide of carbon, naphtha, some of the volatile oils, and especially benzole, are its best solvents. Acids and alkalies exert but little influence upon it.

Hancock, 1823, and Mackintosh, were the first who really applied this gum to its present uses. Their original processes consisted in applying it, dissolved in some of the fluids before mentioned, to the surface of a web of cloth; this might be doubled, constituting a perfectly waterproof garment; but a mass of such laid together became almost inseparable in warm weather, compelling seamen and others much exposed to wet under the tropics to prefer the old-fashioned oil-cloth overcoat to the "Mackintosh." This was remedied by the vulcanizing process discovered by Goodyear.

The modes of manufacture up to a certain point of the manufacture under the old, or non-vulcanizing, and the present, or vulcanizing, processes, are very similar. The mass of rubber bottles, blocks, or strips, were formerly compacted under a hydrostatic press, and afterward cut by knives, operated by machinery, into sheets and strips as required. For forming elastic or corrugated goods the rubber threads were passed between rolls and kept at their full tension during this process, stretching them to several times their natural length; this caused them, when cold, to lose their elasticity. They were then, either naked, or covered with fine thread of silk or cotton, used as the warp or weft threads for the material to be fabricated, and when this was woven their elasticity was restored by passing a hot iron over the goods. Vulcanizing obviates this necessity.

In the present state of the art, the material is first cleansed by extracting the leaves, bark, dirt, and other foreign substances, as far as can be done by hand, and cut into strips by a revolving knife, and then transferred to large fluted iron rollers termed "crackers," which grind out most of the extraneous materials. From the crackers it is taken to the washing-machine, a large vat where it is cut into small pieces by knives, and where it undergoes a kneading and washing process which removes the remaining dirt and foreign matters. It is next transferred to a grinding-machine, composed of large hollow iron cylinders revolving in opposite directions, where the small pieces formed by the washing-machine are kneaded into a homogeneous mass, and is then left to dry. When sufficiently dried,—which takes, perhaps, several months,—the rubber is transferred to the mixing-machine, in which it passes between hollow iron cylinders, heated by steam through their axes to a regulated temperature, where it is farther ground and more thoroughly incorporated. The vulcanizing ingredients are added at this stage of the process.

These may be varied to suit the caprice of the manufacturer, or to adapt the material more particularly to special uses. The combination, through the influence of heat, of sulphur with the gum, gives it the peculiar properties acquired by vulcanization, though other ingredients are largely added.

Charles Goodyear in his original patent preferred 5 parts sulphur and 7 white lead to 25 caoutchouc. The particular proportions of these and other articles are, however, we believe, generally preserved as secrets among rubber-manufacturers, each having special formulas of his own.

Vulcanized rubber is unalterable at a moderate heat, has not the sticky tendency before referred to, and, when cut into threads for elastic goods, does not require to be subjected to a reheating process. This article may be and has been rendered as hard as horn, and used for combs, knife-handles, and even rolled into thin sheets and employed as a substitute for paper.

The substance called ebonite, invented by Mr. Charles Goodyear, who devoted his whole life to the development of the capabilities of caoutchouc, contains from 30 to 60 per cent of sulphur, and has various other ingredients, as shellac, gutta-percha, chalk, barytes, pipe-clay, or white vitriol, added thereto. It is used for knife-handles, combs, and ornamental articles, being very hard and susceptible of a high polish. Equal parts of gutta-percha and caoutchouc combined with sulphur form a compound resembling horn, and which may be used for the same purposes. Sometimes gypsum, resin, or white-lead, are added to this. See IVORY, ARTIFICIAL; HARD-RUBBER; PYROXYLINE; VULCANITE.

Caoutchouc, exposed to a heat of 600° F. in a close vessel, yields an oily liquid which is an excellent solvent of the gum itself.

A very tenacious glue is formed by dissolving the gum in coal-tar naphtha, and evaporating the mixture to the consistency of cream, and adding, when heated, twice its weight of shellac. For use, the

glue is heated to a temperature slightly above that of boiling water. This is known as *marine glue.*

Cap. 1. (*Wear.*) A cover for the head, with or without a visor, but without a brim.

In early times people went bareheaded. An English law of 1571 commanded all persons except gentlefolks and officials to wear a woolen cap.

The Romans long went without any covering for the head, and ancient statues are bareheaded. Caps were once a symbol of liberty, and manumission of a slave was conferred by the gift of a cap. The general use of caps is referred to A. D. 1449. In the reign of Henry VII., hats were limited in price to 20 *d.* and caps to 2 *s.* 8 *d.*, A. D. 1489 In 1571, an act of Parliament made their wear compulsory, except for maids, gentlefolks, land and office holders. See HAT.

2. (*Architecture.*) *a.* The upper member of a column or pilaster. A *capital;* a *corona.*

b. A coping of a wall or parapet.

c. A cornice above a door.

d. The upper member of a molding.

3. (*Carpentry.*) *a.* The lintel of a door or window-frame.

b. A beam joining the tops of a row of posts in a frame. A *plate.*

c. The hand-rail of a stairs or balustrade.

4. (*Nautical.*) *a.* A thick, strong block of wood with a round and a square hole through it, used to confine together the head of one mast and the foot of the one above it; or the jib-boom to the bowsprit.

In smaller craft, a lower cap receives the heel of the topmast, and acts as a substitute for the *fid* and *trestle-trees* used in vessels of a larger description.

b. A parceling or covering at the end of a rope.

5. (*Ordnance.*) *a.* A sheet of lead laid over the vent of a cannon. An *apron.*

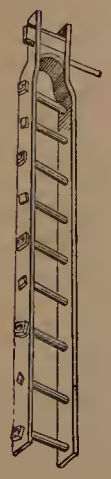
b. A copper capsule containing a fulminate, and placed upon the nipple to explode the charge on the fall of the hammer.

6. (*Machinery.*) *a.* The upper half of a journal-box. The lower half is the *pillow.* See PILLOW-BLOCK.

b. The iron-banded piece (Fig. 1078) on the end of a wooden pump-rod or pitman by which it is connected with a working-beam.

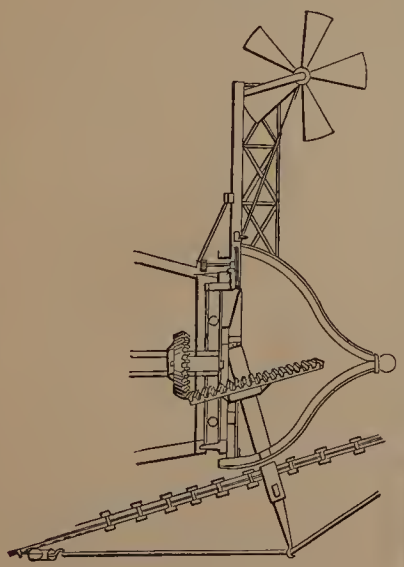
7. (*Civil Engineering.*) The horizontal beam connecting the heads of a row of piles of a timber bridge.

Fig. 1078.



Main-Cap.

Fig 1079.



Windmill-Cap.

8. (*Millwrighting.*) The movable upper story of a windmill. (Fig. 1079.)

9. (*Bookbinding.*) The covering of a head-band or the envelope of a book while binding.

10. (*Horology.*) The inner case which covers the movement in some forms of watches. It is now nearly discontinued.

11. The tire of lead and tin on the periphery of a glazing-wheel.

12. A size of paper. Flat cap is 14 × 17 inches; double cap is 17 × 28; foolscap and legal cap are of various sizes, from 7½ × 12 to the size of a flat cap-sheet folded 8½ × 14. Foolscap is folded on the long edge; legal cap on the top or short edge.

13. A little capsule containing fulminate, placed on the nipple of a gun, and exploded by the fall of the cock to fire the piece. See PERCUSSION-CAP.

Ca-pade'. (*Hat-making.*) A bat.

Ca-par'i-son. (*Menage.*) The bridle, saddle, and trappings complete of a horse for military service.

Ca'pel-li'na. (Sp.) The *bell* or cover of the pile of amalgam bricks (*pina*) in the Spanish process of separating the mercury from the metal. See AMALGAMATOR (Fig. 141).

Ca'per. (*Nautical.*) A kind of vessel formerly used by the Dutch as a privateer.

Cap'il-la-ry-fil'ter. A simple mode of freeing water of its larger impurities by means of a cord of loose fiber, such as cotton candle-wick.

Fig. 1080.

Capillary-Filter.

The water in the upper chamber passes into the wick, and, being elevated by the capillary action, passes down the tube, and drops into the pitcher, which is placed in the chamber to receive it.

Cap'il-la-rim'e-ter. An instrument for testing the quality of oils by indicating the quantity of oil which falls from a given-sized point under certain circumstances of temperature, etc.

Cap'i-tal. 1. (*Architecture.*) The head or uppermost part of a column or pilaster. The capitals of the columns constitute the principal and most indicative mark of the respective orders.

2. (*Fortification.*) An imaginary line bisecting the prominent salient angle of a bastion or other work.

3. (*Distilling.*) The head of a still.

4. (*Printing.*) A large or upper-case letter.

Cap'o-niere'. (*Fortification.*) A work consisting of a double parapet, covering a passage across the ditch to the gorge of the ravelin. See BASTION.

Certain differences in construction give rise to the following names: —

Covered or *casemated* caponiere.

Open caponiere.

Single, *simple*, or *half* caponiere.

Palisade caponiere.

Cap'pa-dine. Silk floss or waste obtained from the cocoon after the silk has been reeled off.

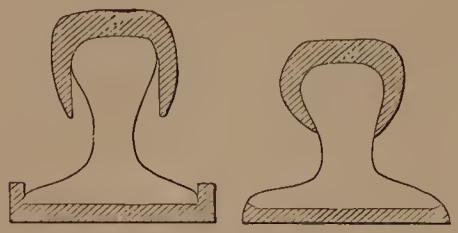
Cap-pa'per. 1. A kind of writing-paper. Ruled with blue lines, and folding on the back, it is *foolscap;* with red lines to form a margin on the left hand, and made to fold on the top, it is *legal cap.*

2. A size of paper from 7½ × 12 to 8½ × 14.

3. A coarse wrapping-paper.

Capped Rail. A railroad rail which has a steel cap attached to an iron body. It is generally made by so disposing the steel in a fagot as to form the edge of that metal, in rolling. It is otherwise

Fig. 1081.



Capped Rail.

known as a *steel-topped* or *steel-headed rail.* See RAIL.

The illustration shows a mode of capping and soling rails as a measure of repair.

Cap'ping-brick. A coping-brick.

Cap'ping-off. (*Glass-making.*) The mode of detaching the closed end of a blown cylinder by drawing a circle around it, bringing it into the shape of an open-ended cylinder ready for splitting longitudinally.

Cap'ping-plane. (*Joinery.*) A plane used for the upper surfaces of staircase rails, which are faintly rounded.

Cap-pot. (*Glass-making.*) A covered glass-pot or crucible.

Cap-scut'tle. (*Shipbuilding.*) The framing of coamings and head-ledges around a hatch and a top which shuts closely into a rabbet.

Cap-square. One of the plates which keep the trunnions of a gun in place. They are secured by keys and chains to the trunnion-plates, which rest in depressions in the cheeks of the gun-carriage.

Cap'stan. A hoisting or hauling machine, consisting of a drum set vertically and revolved by handspikes.

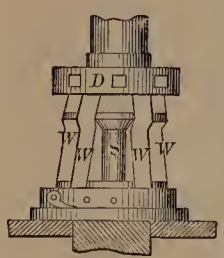
Capstans are *single* or *double*, according as they have one or two barrels upon the same spindle. The double-capstan is revolved by two sets of men on two decks.

They are also known as *fore* or *aft* capstans, according to position. The *fore* capstan stands about midway between the *fore* and *main* masts. The *aft* capstan about the same distance abaft the mainmast.

Capstans were used by the ancient Romans in transporting the Egyptian obelisks.

The drum-capstan for weighing heavy anchors was invented by Sir Samuel Morland about 1661. In a simpler form it was used by the English, French, and Spanish in the fifteenth century.

Fig. 1082.



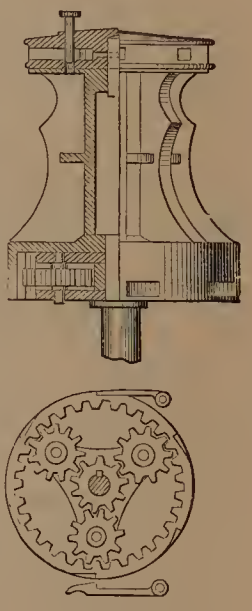
Capstan.

The capstan differs from the windlass in having an upright axle, the bars being placed in the sockets of the *drum-head D*, and revolving horizontally as the sailors walk around, pushing the bars before them, and winding the cable on the whelps, *W*. In this mode of exerting manual power, a force of about 35 pounds is obtained, which is about $\frac{1}{4}$ of what a man can exert upon a windlass, which has a horizontal axis, enabling the men to swing their weight on the bars. The capstan has, however, many advantages among which may be enumerated — compactness, as it does not stretch across the forecastle of a vessel; facility for allowing a large number of men to work at it simultaneously; continuity of its work, as the bars do not require to be unshipped after making a quarter of a revolution.

The capstan has a central, vertical spindle, which passes through one or more decks, and is securely *stepped* at some point below, according to the size and character of the vessel. The spindle, in passing down through several decks, may have arrangements for being worked by men at several levels. Upon the *spindle S* are firmly attached the several parts. The *drum-head D* has square sockets for the capstan-bars, which are about 10 feet long. Under the *drum-head* is the *barrel*, consisting of the whelps *W*, and beneath the *barrel* is the *pawl-head*, which has a series of pawls around its periphery, engaging the notches in the pawl-rim, which is a circular ratchet attached to the deck. The *drum-head*, *barrel*, and *pawl-ring* are firmly attached to the *spindle* and revolve with it, the cable winding on the *whelps* and the pawls preventing back-lash.

In PHILLIPS'S capstan (Fig. 1083), the drum-head is fixed upon the spindle and turns it round. A vertical iron bolt passing through the drum-head locks it to the barrel, and the whole capstan turns round with the spindle, forming a "single purchase." When the locking-bolt is withdrawn, the wheel-work (shown in horizontal section) acts between the spindle and the barrel, and a power of 3 to 1 is gained. The spindle makes 3 turns and the barrel makes 1, and they revolve in opposite directions.

Fig. 1083.

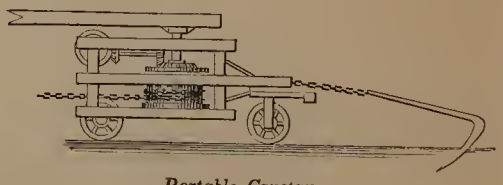


HINDMARSH (English Patent, 1827) added a winch and hand and bevel gearing to the capstan-head, for occasional use. It was partly in the drum-head of the capstan and partly in the barrel.

A portable capstan for the purpose of hauling ditching-machines and mole-plows, moving buildings, and other similar work in which a strong power is to be applied, is shown in the illustration. The chain or rope is wound around the roller, which is in some cases moved by hand-spikes in the hands of laborers, but in the United States is usually moved by a circular sweep and a draft animal or two. It is usually anchored when in use. The sweep is shown as broken off.

Compound Capstan.

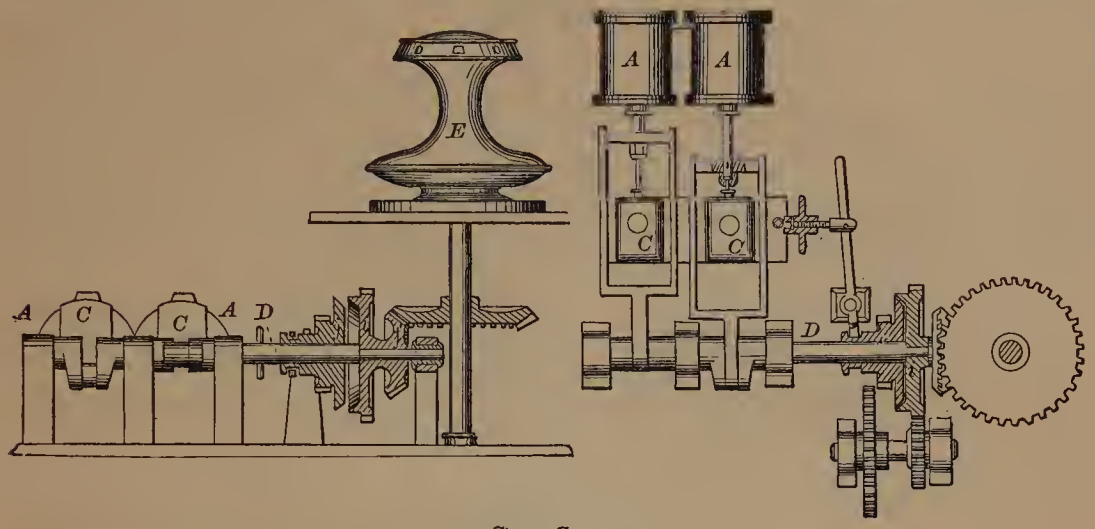
Fig. 1084.



Portable Capstan.

In Fig. 1085 is shown a steam-capstan, in which two cylinders *A A* are connected optionally to the steam-pumps *C C*, or to the shaft *D* of the train, whereby the capstan *E* is revolved. The connections between the pumping-engines and the pumps may be readily uncoupled, and the capstan thrown into gear with said engines. A regulating-screw is combined with

Fig. 1085.



Steam-Capstan.

the friction-clutch, which throws the capstan into gear with the engines, so that the effect of said clutch, respecting the power or speed of the capstan, may be varied.

In moving the mass of granite, weighing 1,500 tons, and used as a pedestal for the statue of Peter the Great, in St. Petersburg, Count Carbury used capstans, the *fall* passing to pulley-blocks, which were secured respectively to the load and to posts set firmly in the ground.

When Vitruvius moved the columns of the Temple of Diana at Ephesus from the quarry to the site, he inserted an iron pin into each end of the column, and to this attached a quadrilateral as long and wide as the column. Oxen were attached to the frame, and the column rolled along on the ground. This was the method devised by Ctesibus of Alexandria. Metagenes, son of Vitruvius, varied the plan in moving the entablature of the same temple, making the iron pivots at the ends of the block work as axles in the hubs of massive wheels. Pæonius suspended his block, which was designed for a pedestal for Apollo, upon wheels in a similar manner. He then united the wheels by scantling, so as to make a perfect cylinder. A rope was wound around this, and uncoiled as the oxen progressed and rolled the cylinder.

Cap'sule. 1. A saucer of clay or bone-ash in which samples of ores or metals are roasted or oxidized.

2. An evaporating dish of porcelain or other ware.

3. A gelatinous envelope for offensive medicine.

4. The shell of a metallic cartridge.

Cap'tive Bal-loon'. One which is tied to the earth by a rope, so as to restrain its ascensive and wandering power.

In the summer of 1868 the largest of its kind was exhibited near London; it had a cubic capacity of 300,000 feet, an ascensional power equal to eleven tons, from which, however, had to be deducted the weight of car and rope, the latter weighing about four tons. It was capable of carrying thirty people with ballast. To render its ascending power as great as possible, pure hydrogen, obtained from water, in place of coal-gas, was used. The resistance or ascensive power of the balloon required a 200-horse-power engine to overcome it and draw it down. See BALLOON.

Car. A wheeled vehicle.

The invention is ascribed to Erichthonius, of Athens, about 1486 B. C. It will not do. Pliny, and other commentators of his day, knew but little of Egypt. (See CHARIOT; CART.) Covered and cushioned cars were used by the Romans. (See CARRIAGE.) Triumphal cars were introduced by Tarquin the Elder, 616 B. C. Cæsar relates that Cassibelaunus, of Britain, after dismissing all his other forces, retained 4,000 war-chariots about his person?

In the United States the term has become restricted almost entirely to vehicles designed for traveling on railways. The varieties are numerous, and are named from their intended use or from some peculiarity in their construction.

Adhesion-car.	Petroleum-car.
Aërial car.	Platform-car.
Box-car.	Provision-car.
Coal-car.	Refrigerating-car.
Dummy-car.	Revolving-car.
Dumping-car.	Safety-car.
Freight-car.	Sleeping-car.
Gravel-car.	Street-car.
Hand-car.	Tank-car.
Irish-car.	Tool-car.
Jaunting-car.	Wrecking-car.

The railway-cars of the United States are carried upon trucks which have a swiveling adjustment beneath the car, to assist in turning curves. This is especially necessary with long cars and on roads with curves of short radius.

The cars of street-railways, being comparatively short, have pedestals for the axle-boxes attached directly to the bed-frame.

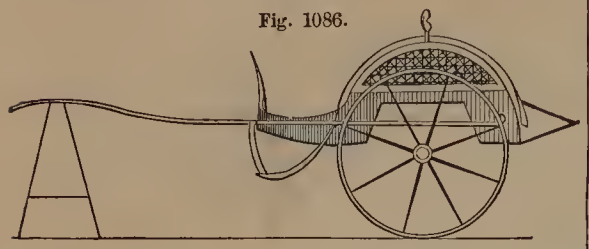
The cars constructed in 1830 for the Liverpool and Manchester Railway, England, had four wheels, but no springs; the bodies consisting of sills, to which the journal-boxes were bolted, and upon which the floors were laid. These cars were formed without roofs. In 1831, one Mr. Joseph Knight proposed to employ springs under all cars, to support the body of the car and contents, and also suggested that the treads of car-wheels should be made conical, for the purpose of facilitating their passage around the curves of the road.

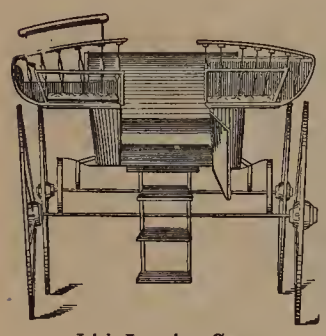
Cars for the transportation of passengers in England and Scotland consist of three classes, the first class being well finished, and provided with seats for the passengers to sit upon, which seats are furnished with cushions. The second class are of plain finish, without cushions or ornaments. The third class are little more than plain boxes set upon wheels and supplied with seats, but in many cases without any

roof. In addition to these three classes, there are what are termed "mixed carriages," which consist of three compartments, the center one being for first-class passengers, and the two end ones for second-class passengers.

The American car has a gangway lengthwise of the car, the seats on each side reversible, so that the car may travel either end forward and yet allow the passenger to "face the horses." It excites the admiration of the average Briton, and will yet be the favorite form of car the world over.

Fig. 1086.





Irish Jaunting-Cars.

3. A kind of two-wheeled Irish vehicle in which the passengers on the two seats sit back to back, facing forward and backward, as in one of the figures; or else sideways, the seats being over the wheels and a well in the center; or else, as in the other figure, a vehicle in which the seats for the passengers face each other, while the driver has a seat in front. Such cars are known as Irish cars, or jaunting-cars.

Car'ack. (*Nautical.*) A kind of large trading-ship, used by the Portuguese in the East Indies.

Car'a-cole. (*Carpentry.*) A term sometimes used for a staircase in a helical or spiral form.

Car'a-co-li. An alloy of gold, silver, and copper, designed for factitious jewelry.

Car'a-core. (*Nautical.*) A light vessel used by the natives of Borneo and the adjacent islands, and by the Dutch as a coast-guard vessel in their East Indian possessions.

Car'at. *a.* A weight of 3.077 grains, used in weighing diamonds.

b. A twenty-fourth part of a piece of gold under assay or estimation.

The name is derived from *Carat*, the sweet-pea, a measure of weight among the Arabs, equal to four grains of barley.

Car'a-van. (*Vehicle.*) *a.* A vehicle for conveying passengers between Cairo and Suez. It is shaped like a light wagon, with top and curtains. A number of them used to meet the passengers arriving by the Red Sea or Mediterranean steam vessels, and convey them across a portion of the Egyptian territory. This route was established by Lieutenant Waghorn.

b. A large inclosed vehicle for conveying wild beasts and other objects of interest in a traveling exhibition.

c. A capacious covered vehicle for moving furniture, etc.

Car'a-van-boil'er. A wagon-shaped boiler.

Car'a-vel. (*Nautical.*) *a.* A small ship, galley-rigged, formerly used by the Spanish and Portuguese.

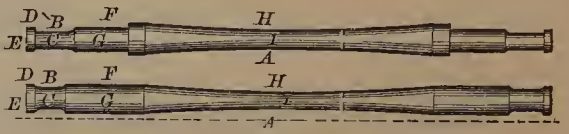
b. A boat used by the French in the herring-fishery.

Car-ax'le. (*Railway.*) The shaft which passes through the *naves* or hubs of the car-wheels, and on which the latter are shrunk or pressed. In the earlier forms of railway car-axles, the wheels rotated on the axles, as in the case of ordinary road-carriages. The practice has long since become almost universal to fasten the wheels of cars to their axles, in order that they may successfully withstand the severe strains and jars to which they are exposed by the weight and surging of the cars and the inequalities of the track.

Axles have been made hollow, to obtain greater strength with economy of metal, but are not in common use, owing to the increased expense of manufacture.

Fig. 1087, *A* shows the form and proportions of an axle.

Fig. 1087.



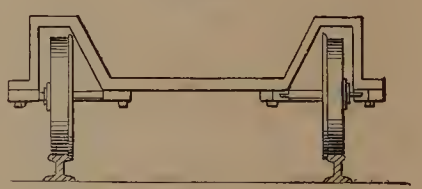
Car-Axle.

E, collar; diameter, $3\frac{3}{4}$ inches.
D, collar; length, $\frac{5}{8}$ of an inch.
B, journal; length, 5 inches.
C, journal; diameter, $3\frac{1}{4}$ inches.
A, axle; length, 6 feet $7\frac{1}{4}$ inches.
F, hub-seat; length, $12\frac{3}{4}$ inches.
G, hub-seat; diameter, $3\frac{7}{8}$ inches.
H, taper; length, 3 feet $6\frac{1}{2}$ inches.
I, middle; diameter, $3\frac{1}{2}$ inches.

In addition to the ordinary form of axle, many devices have been invented, though but few adopted, to obviate special difficulties.

The axle, constructed of one piece of metal, and with the wheels fixed firmly thereon, is subject to severe torsional strain in turning curves, when the outer wheel has a circle of a larger arc to traverse, compelling the wheel on the inner and shorter circle to slip. The torsion of the axle is very detrimental, and the slipping of the wheel is equivalent to grinding on the rail, and retards the train. To avoid these difficulties, the axle has been made in two parts, either by double bearings for the shorter axles, as in Fig. 1088, in which a yoke surmounts the wheels, and is secured to the axle-boxes by screw-bolts, or by some other equivalent arrangement, such as Du Bri's Patent, 1863.

Fig. 1088.



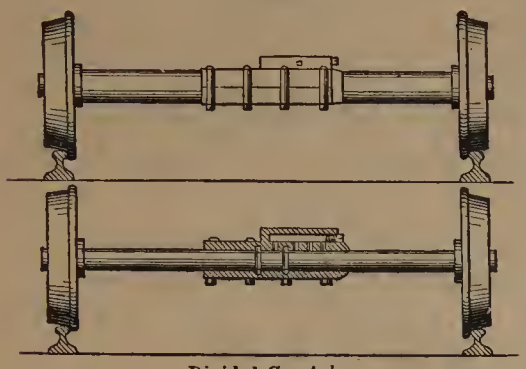
Car-Axle.

Fig. 1089 is an illustration wherein the axle is divided at the mid-length, the inner ends of which are supported in a box or sleeve. See also patent of HEWETT, 1865.

In another form of the divided axle, one portion of the axle is hollow, and forms a sleeve for the other, as in Fig. 1090.

TAYLOR'S car-wheel (English patent, May 11, 1841) specifies an arrangement in which one wheel is fixed to a solid axle, and revolves in a hollow axle affixed to the opposite wheel.

Fig. 1089.



Divided Car-Axle.

These various forms of double axles, which render necessary a multiplication of parts, and consequent

Fig. 1090.

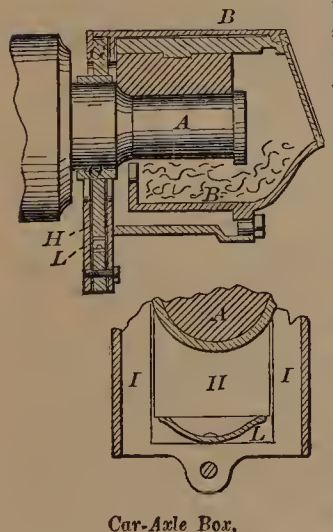
Hollow Divided-Axle.

liability to get out of repair, have never come into general use.

Car-Ax'le Box. (*Railway Engineering.*) The chamber which contains the journal of a car-axle, its lubricant, and *brasses*, and which slides upon and down in the *hanger* or *pedestal* as the springs contract or expand.

In Fig. 1091, *B B* is the box containing the lubricant and its vehicle, tow or cotton. *A* is the journal of the axle, having a collar on its end, to prevent its pulling out. A *saddle* has its seat on the journal, and also forms a key for the collar on the end. *G H* are sections with semicircular grooves, which fit upon the shoulder of the journal and keep out dirt and grit. The upper section *G* acts by gravity, the lower section by means of a spring *L L* beneath it. *I I* are guides for the slide-plates *G H*, which bear against the ring *O* shrunk on the shoulder of the axle.

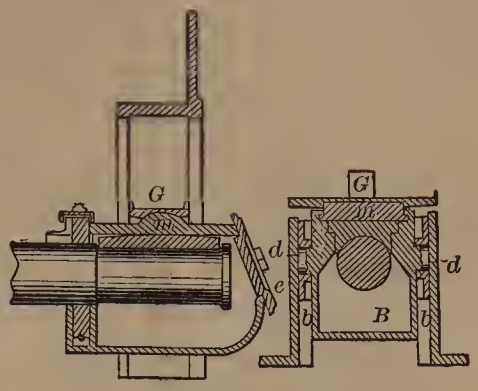
Fig. 1091.



Car-Axle Box.

Fig. 1092 shows the relation of the box to the *hanger*, which may also be clearly seen in CAR-TRUCK. The box *B* has trunnions *d d*

Fig. 1092.



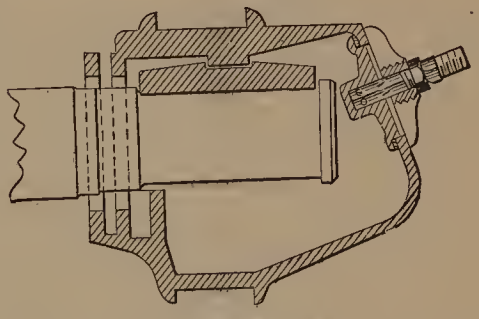
Axle-Box and Hanger.

fitted for sliding blocks *b*, which are adapted to guides formed in the hanger. *G* is the saddle upon which the weight is imposed; this rests upon a plate *m*, and the latter upon the bearing-block or brass which lies upon the journal. *e* is the axle-box cover.

The English railway axle-box has two pieces, divided at the level of the diameter of the axle, at which point it is fastened together by iron bolts. Brasses surround the bearing portion of the axle, which receives oil from a chamber above. An inclined lid on the outside of the box allows the chamber to be replenished with oil when necessary.

Car-ax'le Box-cov'er. (*Railway Engineering.*) The lid on the upper outer portion of the axle-box, which is lifted to renew the oil and tow or other

Fig. 1093.

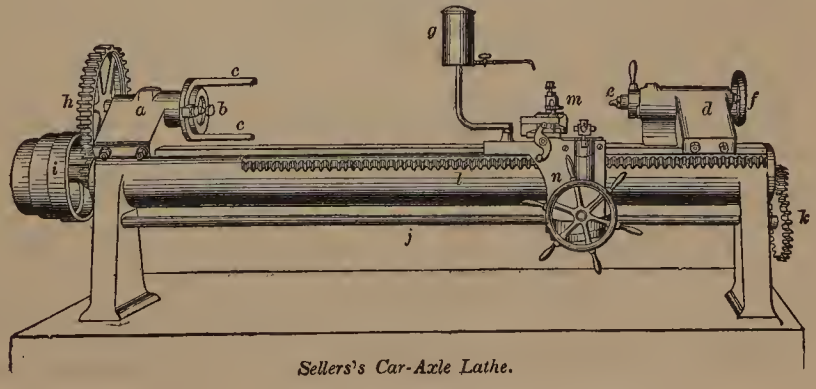


Axle-Box Cover.

lubricating material, and the tow or cotton waste. The lid, usually hinged, fits on an inclined seat, and is secured by latches or otherwise, as in the example, where it is clamped against the inside of the box by a bolt and an outer bridge-piece over the opening.

Car-ax'le Lathe. A lathe specially designed

Fig. 1094.

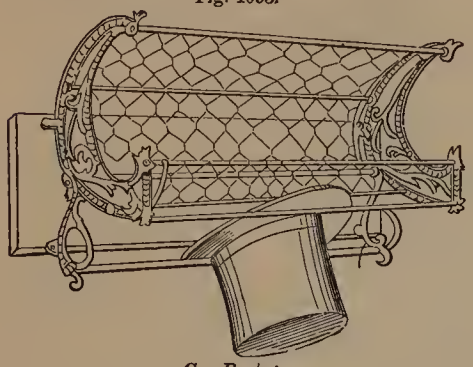


Sellers's Car-Axle Lathe.

for turning car-wheel axles, being strongly geared for heavy cut. The axle is hung upon the centers *b e*, on the head and tail stocks *a d*, and is rotated by the Clement driver *c* on the face-plate, which derives its motion from the gear-wheel *h* and band-pulley *i*. The slide-rest *n*, which carries the cutter *m*, has an automatic feed-motion by the rod *j*, wheel *k*, pinion and connections, and also a rack-feed *l*, with quick hand-traverse. The working parts are fended from chips, and also from the water which drips from the can *g* upon the cutting-tool.

Car-bas'ket. (*Railway.*) A shelf or rack in a

Fig. 1095.



Car-Basket.

passenger car to contain small packages, shawls, satchels, hats, etc.

Car'bine. A small arm with a short barrel, adapted for the use of cavalry, and having a bore of .44 or .50 inch, or thereabout.

They appear to have come into notice in the army of Henry II. of France, 1559. The arm was 3½ feet long, and the practice was to fire and fall back behind the rear rank, who fired and followed suit. The troops were light cavalry, and the arm seems to have had a wheel-lock.

The term now is applied to a short gun adapted for cavalry, of which many breech-loading varieties have been tried in the United States army with greater or less success. Previous to the general introduction of breech-loaders, the fire-arm in common use for cavalry, as well as engineers and heavy artillery, was a species of carbine denominated musketoon, differing from the musket only in length and in the fact that the arm for the cavalry was provided with a sling-bar for more convenient carriage on horseback; those for the engineers and artillery were generally furnished with sword-bayonets. These all appear to have corresponded nearly in caliber and general dimensions with the modern French *carabine*.

The *Spencer* rifle was extensively used by the cavalry of the Union army during the late war.

Car'bine-thim'ble. A stiff leathern socket, secured to a *D*-ring on the off-side of the saddle by a strap and buckle. It receives the muzzle of the horseman's carbine.

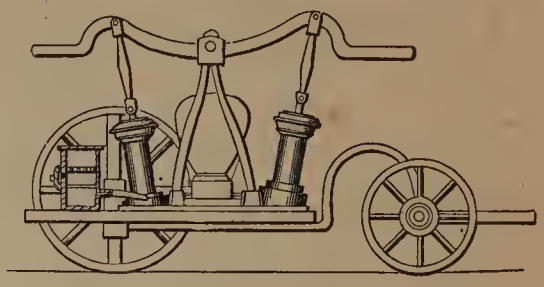
Car'bon-bat'ter-y. Another name for the "Bunsen" galvanic battery, in which carbon or gas-coke replaces the platinum of the "Grove" battery, and a solution of bichromate of potash replaces the nitric acid. The carbon is sometimes in the form of a cup, and thus constitutes the porous cup as well as an element. Sometimes known as the Electropoion Battery, though this is a generic term, and is equally applicable to other forms. See BUNSEN BATTERY.

Car-bon'ic-a'cid En'gine. 1. An engine driven by the expansive power of condensed carbonic-acid gas. BRUNEL'S gas engine, 1804, was driven by the increment of pressure due to the passage of hot water through a coil in the gas-reservoir. See GAS-ENGINE.

2. A machine for impregnating water with carbonic-acid gas as a beverage. See AËRATOR.

3. A form of fire-engine in which water is ejected by the pressure due to the evolution of carbonic

Fig. 1096.



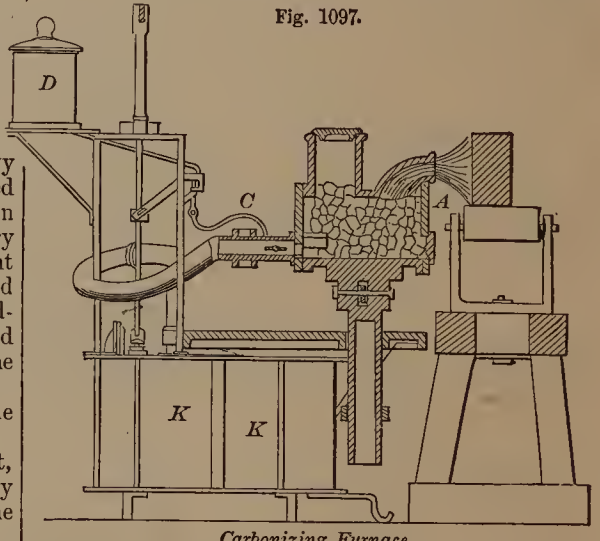
Carbonic-Acid Engine.

acid in a closed chamber over water; or in which carbonic acid is ejected with the water, in order to assist in extinguishing fire by the exclusion of oxygen therefrom. In the example (Fig. 1096), the pumps are made to discharge water, into which a stream of carbonic acid is constantly driven by an air-pump after the water has left the pump-cylinders. See FIRE-ENGINE; FIRE-ANNIHILATOR.

Car'bon-iz'er. A tank or vessel containing benzole, or other suitable liquid hydrocarbon, and through which air or gas is passed, in order to carry off an inflammable vapor. See CARBURETOR.

Car'bon-iz'ing-fur'nace. An apparatus for carbonizing wood, disintegrating rocks, etc. Composed of a furnace or fire-chamber, movable upon a stationary frame, both vertically and horizontally, and pro-

Fig. 1097.



Carbonizing Furnace.

vided with a nozzle, by which the flame is directed upon the object. The furnace is connected to a blast-apparatus *K K* by means of a flexible tube and a pipe; a fine stream of water flows into this tube from a tube *C* connected with a water-reservoir *D*, and the pipe is surrounded by a water-chamber, to prevent the heat from affecting the flexible tube. The wood to be acted upon is passed before the nozzle *A*, being supported on rollers attached to a suitable frame.

Car'bon-light. The light produced between and

upon two carbon points, between which passes a current of electricity. See ELECTRIC LIGHT.

Car'bon-om'e-ter. An instrument to detect the presence of an excess of carbonic acid by its action upon lime-water.

Car'bon-print'ing. In 1838 or 1839, Mr. Mungo Ponton first pointed out the effect of light in producing colorable changes in compounds of bichromate of potassa and organic matters. Mr. Fox Talbot appears to have been the first to appreciate the effect of light in rendering insoluble the compounds of bichromate of potash and gelatine. Poitévin, in 1855, was the first to use carbon, adopting the bichromate of gelatine as a vehicle, availing himself of its insoluble character after exposure. The process was as follows: Paper was coated with a compound of bichromate of potassa, gelatine, and lamp-black, in cold distilled water; this is allowed to dry in a dark room, subsequently exposed beneath a negative for a few minutes, according to the character of the solution and of the light, then dissolving off with hot water the parts not affected by the actinic action of the light. The picture resulting from this treatment is a positive print in black and white, of which the shades are produced by the carbon of the lamp-black. Poitévin also introduced various colors into the same process.

Poitévin, later, introduced another process for carbon-printing under a *positive*. The paper is floated in a bath of gelatine dissolved in lukewarm water and colored with lamp-black. Such paper is sensitized in a dark room by immersion in a solution of sesquichloride of iron and tartaric acid. This renders the gelatine insoluble, even in boiling water. The sheets are dried and exposed under transparent positives in the printing-frame. The parts of the film acted upon by light become soluble in hot water, the iron salts, under the influence of light, being reduced by the tartaric acid, restoring the organic matter to its natural solubility. The sheet is then washed in hot water, which removes the ferruginous compound and develops the picture.

Swann, of Newcastle-upon-Tyne, about 1861, was the first to introduce into a practical process the transfer of the film, after exposure, to another surface, with the face of the film downwards, so as to admit of the dissolving off of the unaltered gelatine and pigment, without undermining the delicate portions of the picture. It will be manifest that the depth to which the actinic rays penetrate the film differs according to the transparency of the negative, and with the light tints will penetrate but a very short distance. With such tints, — when the solution takes place from the face, — when the free gelatine comes to be dissolved, the thin coating of insoluble gelatine and pigment representing the more delicate shades becomes undermined and floats away. Swann, to avoid this, transferred the film with its affected side downward on a sheet of paper, washed from the back of the film, and transferred back again to the paper on which it remained.

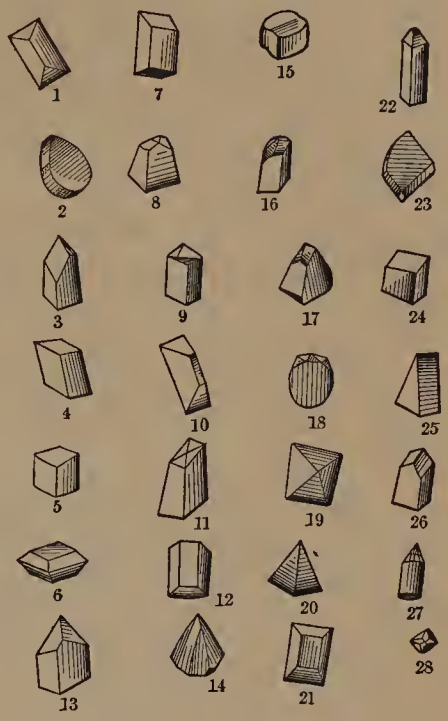
Argentotype is a modified form of carbon picture introduced by Wenderoth, in which the print is backed by a polished plate, to bring up the high lights. Johnson proposes tin as a substitute, cheaper and less likely to tarnish.

The carbon process has been carried forward in several different directions. A hardened film of bichromated gelatine has been pressed in a sheet of lead in a hydraulic press, and a reverse in lead obtained, from which gelatinous casts may be taken. See WOODBURY PROCESS.

The gelatine film carrying the impression is used to print from directly in ordinary ink. See HELIOTYPE.

Car'bon Tool-point. An application of the diamond to mechanical purposes. These points are used to point, edge, or face tools for drilling, reaming, sawing, planing, turning, shaping, carving, engraving, and dressing flint, grindstones, whet-stones, emery, corundum, tanite, or tripoli wheels, iridium, nickel, enamel, crystals, glass, porcelain, china, steel, hardened or otherwise, chilled iron, copper, or other metals.

Fig. 1098.



Dickinson's Carbon Tool-Points.

1 is a triangular prism-like cutter for turning or working stone, etc.

2 is a flat drill-point for drilling stone, glass, or metal.

3 is a burin for cutting or turning metal.

4 is a quadrangular prism for working stone, etc.

5 is a hexahedron to be inserted in the edge or face of a circular saw for cutting stone.

6 is a double-sided trapezoid, used in various positions for marking or turning stone, steel, or other substances.

7 is a chisel point or cutter for turning metal, etc.

8 is a drill-faced parallelogram for pointing combination drills for drilling and reaming stone, metal, etc.

9 is a quadrangular prism with a planer cutting-point for cutting or planing metal, etc.

10 is a truncated prism for working stone, etc.

11 is similar to 8, and used for the same purpose.

12 is a truncated prism used for facing or edging ring or cylinder drills and circular saws for cutting stone, metal, etc.

13 is a quadrangular double-faced drill-point for drilling stone, etc.

14 is a quadrangular pyramid used for reaming stone or metal.

15 is similar to 5, and is used for the same purpose.

16 is a quadrangular cube with graver-edge for cutting metal, etc.

17 is a flat octahedron for drilling stone, glass, etc.

18 is a flat ovoid; with double drill-point, for drilling or countersinking stone, metal, etc.

19 is a tetrahedron, used the same as 18.

20 is a pyramidical drill-point, used the same as 18 and 19.

21 is a truncated prism, used the same as 1 and 10.

22 is a drill-pointed prism-reamer.

23 is similar to 22, and used in the same manner.

24 is the same as 7, with angular edges, and used for the same purpose.

25 is a double-inclined plane-wedge for cutting stone or metal.

26 is a quadrangular wedge for turning stone or metal.

27 is an acute conical-turned diamond-point, used for engraving, etching steel by bank-note engravers.

28 is a diamond in its natural crystallized state, as found in the mines.

Car'boy. A large globular vessel of green glass inclosed by basket-work or a box for protection. In the latter form the box has rope handles, and the mouth and neck of the carboy protrude through the top of the box. It is used for carrying chemicals, such as sulphuric acid, the *vitriol* of commerce, of which it contains 160 pounds, or 12 gallons of water.

It is like a *demijohn* (*damaghan*, Persian) except in its purpose. The latter is intended to contain spirits.

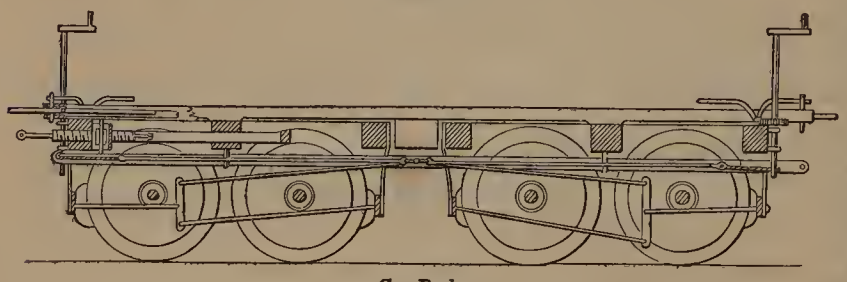
Car-brake. (*Railway Engineering.*) An apparatus by which pressure is applied to the wheels of railway cars, to check their speed and eventually stop their revolution.

The usual accessories are the

Brake-wheel.	*Shoe.*
Brake-lever.	*Rubber.*
Brake-bar.	

1. The brake is usually hand-operated by the brakeman or guard on the car platform or roof, as the case may be. Passenger railway-cars and street-cars have on the platform a brake-wheel or lever, the revolution of whose axis winds up a chain which actuates the levers, rods, bars, and shoes, as in Fig. 1099, and the apparatus is kept at its tension by a click working into a ratchet-wheel on the stem of the brake-lever. The illustration shows an arrangement of longitudinal brake-rods beneath the cars, connected together by chains, so that the brakes are brought into operation if any of the car-couplings give way.

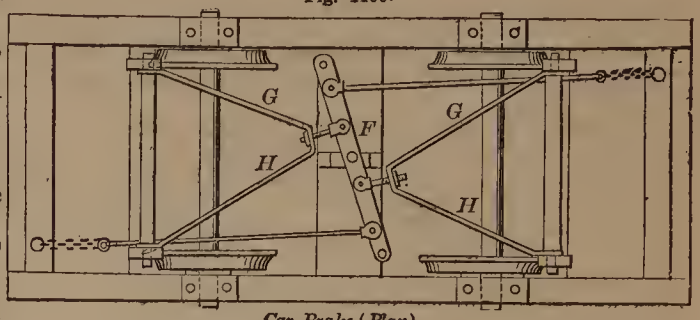
Fig. 1099.



Car-Brake.

One form of the system of rods and bars beneath the car is shown in Fig. 1100, in which a single lever *F*, pivoted at mid-length, is operated by chains and rods from the brake-wheel on either platform. To the lever are attached rods *G H*, proceeding to the brake-bars, which carry the shoes.

Fig. 1100.



Car-Brake (Plan).

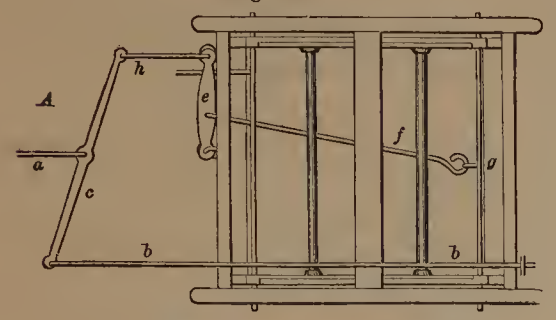
Fig. 1101, *A* is a plan of the Hodge brake, invented in 1849. The illustration shows the portions belonging to one truck; the rod *a* passes to the other truck, where the braking-devices are repeated, so that the action on the wheels of both trucks is coincident and equal, by motion derived from the brake-wheel on the platform at either end of the car. *b* is the rod which is pulled endways by the winding of the chain on the stem of the brake-wheel. This rod *b* pulls upon the lever *c*, which is pivoted at mid-length to the rod *a*, and at its other end by rod *h* to the lever *e*, which is a lever of another order, and transmits to the rod *f* and brake-bar *g* half the power exerted upon *b*. It will be seen that the end of lever *e* attached to the rod *h* is the fulcrum for the attainment of effect on the rod *a*, while the latter is the fulcrum for rod *h*; each is a moving fulcrum, and, the effect upon each being equal, the force of the man upon the brake-wheel is evenly divided between the wheels of the respective trucks.

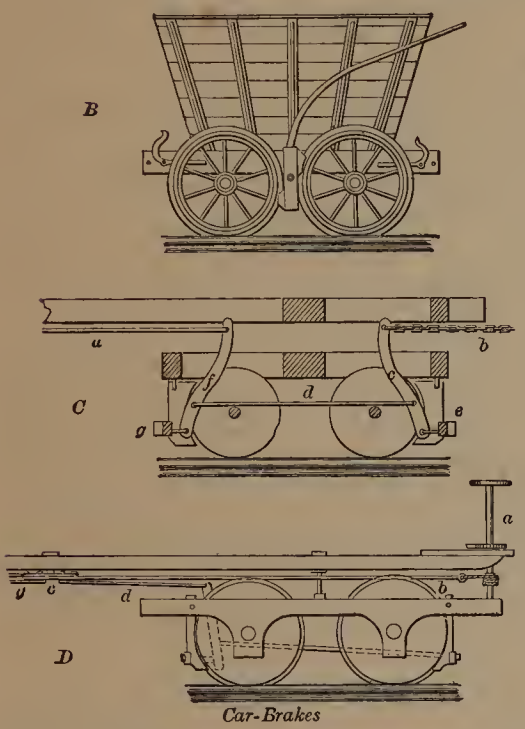
Fig. 1101, *B* shows the English form of lever-brake for coal or gravel cars. It has a bar pivoted to the frame, and a shoe to act upon each wheel as the lever is depressed.

Fig. 1101, *C* is the Stevens brake, 1851, in which the action of the brakes on the wheels of the respective trucks is also coincident and equal. The drawing shows but one truck, but the rod *a* connects the levers of the respective trucks, so that the operation from either end is effective upon the whole, the result being more thorough if the brake-wheel of the far end be left locked, so as to form an ultimate fulcrum for the system of levers set in motion from the, for the time, operative end. A pull on the chain *b* vibrates the lever *e* on its fulcrum, the rod *d*, and brings the shoe *e* against the wheel; but the fulcrum is itself moved, and, by drawing on the rod *d*, moves the lever *f* and draws the shoe *g* against the other wheel. In effecting this, the upper end of the lever is made the fulcrum; but this is itself movable, transmitting by rod *a* one half of the force originally expended to the braking apparatus of the other car.

Fig. 1101, *D* is another brake of allied nature, the force of the rotation of the brake-wheel stem *a* in winding on the chain being transmitted by rod *b* to a wheel *c* under the center of the car, and thence by rods *d g* to the levers which operate the brake-bars of the respective trucks. The course of the connecting-rod between the two brake-levers of a truck is

Fig. 1101.



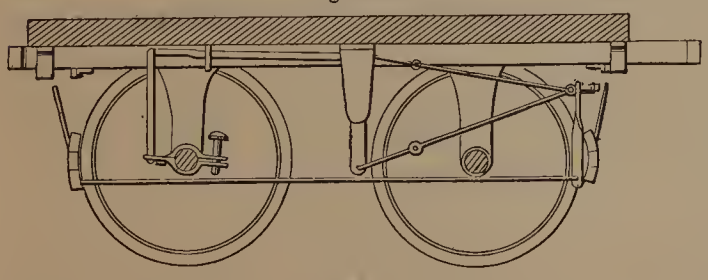


Car-Brakes

drawn in dotted lines, representing it as on the other side of the wheels.

2. The devices are numerous in which the colliding of the cars, as the rate of motion is slacked, or as the brake is put upon the engine or forward car, is made to put the brakes of the train in operation, the effect of the brake-action being proportionate to the energy with which the forward car or engine opposes the momentum of the cars following. One form is shown in Fig. 1102. When the engine is checked

Fig. 1102.



Car-Brake.

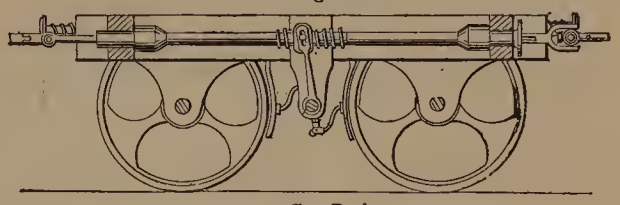
and the buffer-bars come together, the brakes are applied to the cars by power derived from the sliding motion of the buffer-bars and transmitted through the medium of the rods and levers.

The action in this case is by the bumping of one car upon another. In Fig. 1103, the brake-bars of a train are simultaneously worked by means of longitudinal connecting-rods under the car-beds and gimbal-joint connections between cars. The longitudinal screw-shaft turns in bearings in the truck, and operates a nut which is connected to and actuates the brake-levers.

3. Brakes operating continuously throughout the train are found in the patents of Marks, 1854, acting by rods and chains; Stewart, 1859, having rods and cog-wheels; Burrows, 1862, by rods and levers.

Devlan's patent of 1861 acts by grasping the axle

Fig. 1103.



Car-Brake.

of the wheels; Blanchard's, 1866, by a shoe on the rail.

Of the car-brakes exhibited at the Paris Exposition, 1862, Creamer's was automatic, instantaneous, and simultaneously applied to all the wheels of each car.

The machinery of the system in common use remains unaltered, but there is added to it a reserved power in the form of a closely wound and powerful spiral spring, which may be set free by the pulling of a trigger, and which, when free, is a substitute for the force of the brakeman. The apparatus is under the control of the engineer or the conductor, on any car.

With Achard's electro-magnetic brake, each carriage in the train is supplied with a battery of six Daniell cells, connected with each other and with the engine foot-plate by means of four insulated wires passing through the whole length of the train. By means of these electric wires two distinct electric currents may be created, either of which may be closed or broken by altering the position of a handle placed before the engine-driver. The electro-magnetic force upon an armature on each car is made to wind a barrel and draw upon a chain which vibrates the levers and applies the brakes.

4. Another class of car-brakes consists of those in which braking-devices of the cars individually are operated by means of an elastic fluid, air or steam, the operative devices of each car being under the control of the engineer, upon the locomotive.

Steam-operated devices are of different forms: —

a, steam-pipes connected throughout the train and operating a piston in a cylinder on each car, to work the brakes.

b, a rod and chain connected throughout the train, the operative devices being a single cylinder on the locomotive.

c, an air-pipe connected throughout the train, a cylinder and piston beneath each car to operate the brakes, an air-pump on the locomotive to condense air, which is carried by the pipes to all the cylinders in the train.

The Westinghouse Air-Brake employs atmospheric air as the medium for transmitting power to the brakes. This is condensed to the required ex-

tent by a steam-pump placed between the driving-wheels or in other convenient position on the locomotive. The air is forced into a reservoir, so that a sufficient supply may be ready for use. From this reservoir it is conducted back under the cars of the train by pipes, connected between the cars by india-rubber hose and valved couplings. Under each car is a cylinder to which the compressed air is admitted forward of a piston, the stem of which is connected to a bell-crank attached to the brake-levers by rods, so that, when air is admitted in front of the piston in the cylinder, the brakes are at once applied to the wheels. See BRAKE, p. 356.

There have been numerous attempts to secure automatic and simultaneous action, throughout the cars of a train, by power derived from a single impulse or operation. Room cannot be spared for their systematic description, but the following patents may be consulted : —

Bessemer (English)	1841	Hodge	1860
Hancock (English)	1841	Dwelley	1865
Nasmyth (English)	1839	Davidson	1860
Petit	1840	Marsh	1864
Birch	1840	Virdin	1859
Carr (English)	1841	Wilcox	1856
Walber	1852	De Bergues	1868
Fuller	1859	Chatelier	1868
Sickels	1857	Lee	1868
Cuney	1855	Ambler	1862
Goodale	1865	Branch	1858
Peddle	1867	McCrone	1865

Car-buf'fer. (*Railway.*) A fender between cars. In the English practice, the ends of the car-frames carry elastic cushions, or buffer-heads with springs. In our practice the spring is usually behind the draw-bar. See BUFFER.

Car-bump'er. An elastic arrangement to lessen the jerk incident to the contact of colliding cars as the rate of speed is slackened. See BUFFER.

Car'bu-ret'or. An apparatus through which coal-gas, hydrogen, or air is passed through or over a liquid hydrocarbon, to increase or confer the illuminating power. They may be said to be of two kinds, though the purpose differs rather than the construction : —

1. For enriching gas.
2. For carbureting air.

The former of the two was the primary idea ; the latter was suggested as the matter was developed.

By carbureting the gas you may use poorer coal. Bituminous coal gives off different gases, according to the quality of the coal and the way it is distilled, and gives off different qualities of gas at different stages of the process of distillation. The value of the gas as a lighting medium depends upon the quantity of volatile hydrocarbons ; and the object of passing it through the benzole of coal-tar or the volatile oils derived from petroleum is to enrich the gas by the addition of hydrocarbon vapors. Where city gas is not available, air may be carbureted, that is, saturated with the inflammable vapor, by passing it through the liquid. There are many difficulties in perfectly accomplishing the carbureting of air or gas : —

1. The hydrocarbon vaporizes more readily in warm weather than in cold, so that the degree of saturation depends in part upon the temperature of the weather.

2. The liquids used for carbureting air are not homogeneous, but are a mixture of liquids of various volatility ; after charging the carburetor, the lighter will pass off first and leave a heavier and less volatile residuum.

3. The amount of vapor taken up will depend upon the speed with which the air passes through the carburetor ; so that, when the number of burners is varied, a certain change follows in the quality of the gas.

4. The material is very inflammable, and leaks of the liquid or the vapor are dangerous, requiring special provisions for safety and the attention to charging by daylight.

5. The chief difficulty arises from the fact that the volatilization of the hydrocarbon is affected by the intense cold produced by the evaporation of the liquid.

The working up of the coal-tar oils preceded the discovery of petroleum in commercial quantities.

The primary idea was to force the gas through the liquid.

Carburetors of gas may be defined as those in which material rich in carbon is added to the usual charge of coal in the retort.

Those in which a liquid hydrocarbon is evaporated by the heat of the burner, and mingles with the usual carbureted hydrogen gas.

Those in which the gas is exposed at atmospheric temperature to the liquid hydrocarbon, so as to exhale from the latter a vapor which passes with the usual gas to the burner.

Lowe, in England (English patent 6,276, June 9, 1832), was for enriching the commercial carbureted hydrogen by filling the meter with coal-tar naphtha instead of water, the meter-wheel being driven by the force of the gas from the main. The uniform hight of the liquid in the meter was secured by a fountain arrangement such as is used in lamps, ink-stands, mucilage-cups, and bird-glasses. He subsequently applied (No. 8,883 of March 16, 1841) power to turn the meter-wheel. He also proposed to pass the gas through sponge, or other animal or vegetable stuff or fiber, the said matter being from time to time saturated with naphtha. Also to expose the result to a caustic alkali, to remove the sulphur, and to an acid, to absorb the ammonia.

He also arranged a number of troughs one over another in a box ; these discharged into each other by overflow tubes ; air is admitted below, sweeps over the surfaces of the liquid in the successive troughs, and passes out at the top.

Also a box having vertical partitions, with sponges, fragments of pumice-stone, or coke impregnated with naphtha, in the compartments, through which the gas passes in succession, up and down, and so on throughout the series.

Selligue, 1834, carbureted hydrogen gas produced by the decomposition of water, and afterwards enriched the products of destructive distillation of wood, resins, oils, etc.

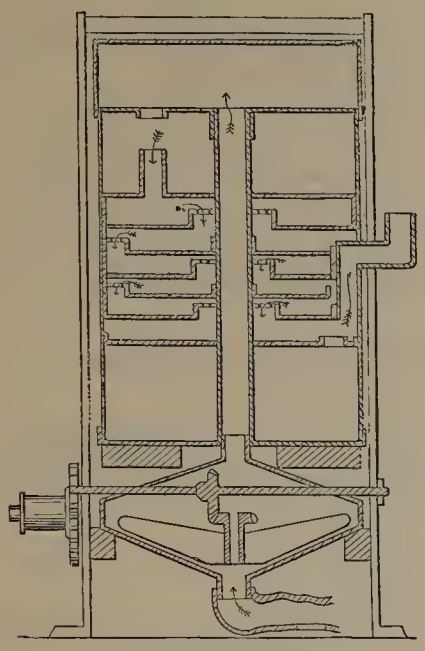
This idea was afterwards followed out by a number of inventors.

C. B. Mansfield, who obtained an English patent (No. 11,960, November 11, 1847), gave a stimulus to the business by the production of a suitable liquid. He did as much, apparently, as could be done with coal-tar benzole, and died from the effects of an explosion of the saturated air.

Drake, 1853, revolved a porous material, to expose a saturated surface to a blast of air.

Adams had a series of overflow pans somewhat as in the cut (Fig. 1104). The air is driven by the rotary fan in the chamber below, through the central vertical pipe to the upper chamber, from whence it passes in a circuitous, reverting, downward course, in contact with the hydrocarbon liquid in the successive trays, and thereby becomes impregnated with vapor.

Fig. 1104.



Carburetor.

Lecarriere, in France, in February, 1853, began by carbureting hydrogen produced by the decomposition of water in the presence of zinc and acid, and then passed to the carbureting of air. He employed a number of cylinders in a box, making a sinuous course for the gas, which enters at the middle, passes down and out through small holes into the second cylinder, and so on. He also introduced a regulating-float.

Marchesson, in 1853, had an upper supply-vessel with a lower chamber, containing a conduit of spiral form, divided by partitions into chambers provided with absorbents, and which communicate by holes. A variation of this was an Archimedean screw moved by the gas, which was enriched by the vaporized liquid.

Launay, 1856, used cotton wicks saturated with oil by capillarity, and exposing a large surface to the passing gas.

Veique, 1857, has a closed cylindrical chamber, with inlet and outlet pipes for the gas, and a revolving helix of wires or a helical frame with wide-meshed cloth.

Varmaique, 1858, has a siphon arrangement for the supply of an upper chamber, which discharges by a pipe at the bottom of the lower chamber; the gas passes through the chambers.

Vesian, 1858, introduced the float operating the valve of the admission pipe for the liquid.

Martin, 1858, added a lamp, to expedite the vaporization.

David, in 1859, used a bulb of displacement, to preserve a constant level, instead of an automatic valve of admission; and this was so arranged as to maintain a uniform hight, although the liquid varied in density as evaporation proceeded.

Ashcroft, 1857, had a float to govern the ingress of air, and cause it to pass through a uniform depth of liquid.

Levi L. Hill, 1859, reissued 1863, modified the richness by inlet of air, and had a double bellows for equable blast.

F. S. Pease had a separate tube to condense an excess of liquid.

Lowback, 1860, heated the air.

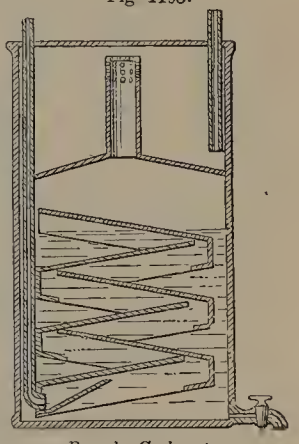
Matters remained in this condition until the discovery of petroleum; the first notice of petroleum benzine was in a Boston paper, September, 1860.

John A. Bassett, by patent March 2, 1862, developed the use of the petroleum liquid, which gives the carburetor its practical value, the gas-tar products being expensive and difficult to manage.

Levi Stevens, December 20, 1864, passed the air through a shower of the liquid, which was dropped into the vaporizer in measured quantities.

Irwin introduced a feature (April 11, 1865) founded on the fact that the hydrocarbon vapor conferred greater gravity upon the air, so that the weight of the carbureted air forced itself to the burner and dispensed with a blowing apparatus. He also used a caloric engine to produce a motive-power to generate a blast of air, and the escaping heated air was carbureted.

Fig 1105.



Pease's Carburetor.

Boynton, 1865, dispensed with moving machinery in the chamber, by making a plain metallic box with a fibrous material inside, through which air was forced. He also mixed the benzoles of gas-tar and petroleum.

Myer, 1865, washed the carbureted air, to remove extraneous matters.

Pease, 1865, injected air at the lower portion of the carburetor, causing it to ascend through fluid in contact with the lower surfaces of a series of inclined planes with flanged edges and ends, passing from one incline to another in a zigzag upward course into the chamber, from whence it is withdrawn for use.

After this the inventions became very numerous, having reference mainly to detail: to regulate the admission of air, the egress of carbureted air, the graduation of the quantity of liquid admitted, a forced circulation in the carbureting chamber; to regulate the temperature of the liquid, the air, and the result; means for drawing off the heavy oil.

As means of forcing the air: —

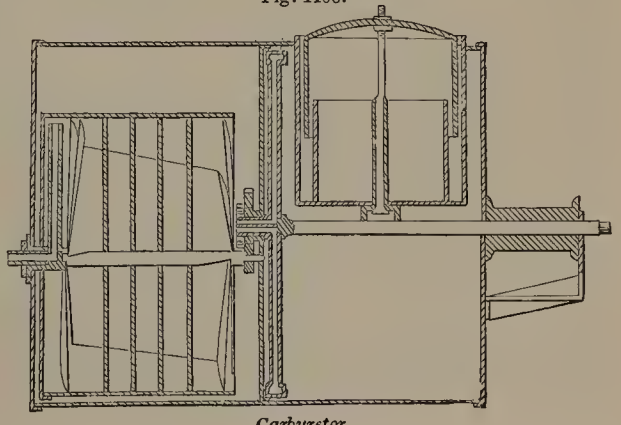
Bassett and McAvoy use the weighted gas-holder, the inverted cylinder whose lower edge is immersed in the water of an annular chamber.

Prichard forced the air by water under pressure, admitted below to expel the air from the chamber.

Douglas's has a rotary fan.

Levi Stevens's has a meter-wheel, whose shaft has

Fig. 1106.



Carburetor.

its bearing below the center of the partition dividing the meter and regulation chambers, and gears with a wheel on the regulator-shaft, which has a bearing at the center of the partition. Both chambers are partially filled with carbureting liquid. Air is introduced to the top of the meter-chamber. As the air is carbureted it is conducted to the regulating-apparatus.

Car-cab. (*Railway.*) The shelter on a locomotive for the protection of the engineer and stoker.

Car'cass. 1. (*Architecture.*) The naked shell of a house, sides and roof without floors, joiner's work, or plastering.

2. (*Shipwrighting.*) The keel, keelson, stem and stern posts, and ribs of a ship.

3. (*Ordnance.*) An incendiary projectile filled with a composition of saltpeter, sulphur, resin, turpentine, antimony, and tallow. It has three vents for the flame, and sometimes pistol-barrels arranged to discharge occasionally. It is discharged from a mortar or howitzer, and is intended to set fire to buildings, ships, or wooden defenses.

Car'cass-roof'ing. (*Carpentry.*) That which supports the covering by a grated frame of timberwork.

Car'cass-saw. A kind of *tenon-saw.* The blade is strengthened by a metallic backing, which is bent over, and closed upon it with a hammer. It has eleven teeth to the inch.

Car'cel-lamp. A lamp of French origin, in which the oil is raised to the wick by clockwork. A mechanical lamp, used in lighthouses, where the wick is overflowed with oil as a measure of equality of supply and of safety to prevent overheating of the wick and wick-tube. See MECHANICAL LAMP.

Car-couch. A chair which may be converted into a lounge for night-traveling.

A bunk or lounge in a sleeping-car, made up of two opposite seats with an intervening bridge-piece, or of a shelf let down from above.

Car-coup'ling. (*Railway.*) A device for connecting the cars in a train.

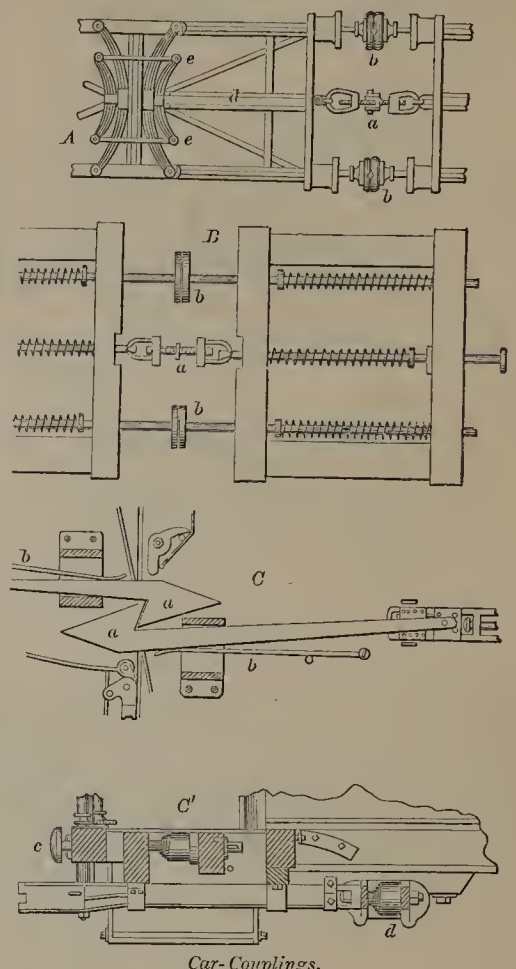
In the United States this is usually a form of shackle, but in Europe the connection is more intimate, the cars being coupled together so firmly as to prevent the jar as the cars collide or jerk apart in stopping and starting. This mode of coupling is also found in many United States railways, especially where the steam or air brakes throughout the train are operated by the engineer.

The English car-coupling (Fig. 1107, *A*) is a right and left screw-shackle, *a* on the median line making a connection sufficiently rigid to somewhat compress the *buffers b b* on each side. In some cases the *buffers* of adjoining cars are connected by chains, and their rods act as pistons in tubes provided with springs; the cars are thus coupled by the buffers. The *draw-bar d* of the coupling is connected to an elliptic spring *e*, which diminishes the jerk of the cars when starting the train.

Some of these features are also found in *B*, which is an old form of United States coupling with buffers, copied from the English, from whence we early received our railway engines and cars. The drift is now the other way across the Atlantic.

C C' are respectively plan and elevation of the Miller coupling, which connects automatically as the respective point-headed hooks come in collision. A sufficient amount of lateral play is allowed to the hooks *a a* to allow the wedge-shaped surfaces to slip past each other, and springs *b b* at the rear of each keep them in engagement when once connected. Special means are used to withdraw the hooks from each other when they are to be uncoupled. The

Fig. 1107.



Car-Couplings.

lower view, *C'*, shows the mode of engagement less clearly, but exhibits also the spring buffers *c*, above the hooks, which act as fenders to the cars, and deaden the blow as the cars surge against each other in checking the speed of the train. The coupling-hooks themselves have also springs *d* for the same purpose.

In Fig. 1108, *D* is a falling latch-hook.

E has a gravitating hook *a*, with a spring which allows it to yield to the thrust of the entering link *b* in the act of coupling. On the back of the hook *a* is a handle *c*, which is lifted to uncouple the link.

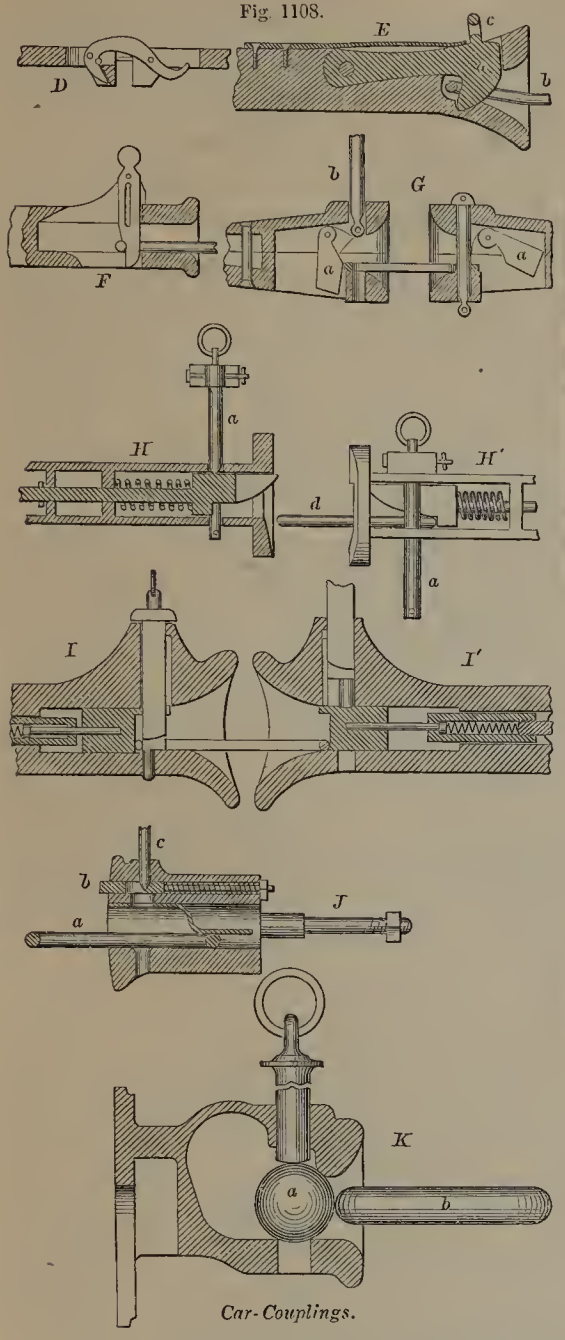
F has a vertically sliding bolt, which rises automatically as the link collides with its lower inclined portion when coupling, and then falls down into engagement.

G shows a pair of draw-heads in which the tumbling-latch *a* holds up the pin until thrust back by the entering link. The pin *b*, when fixed for automatic coupling, rests on the toe of the latch, as in the left-hand draw-head; the link pushes back the latch and allows the pin to drop from the toe, as in the right draw-head.

H H' are two draw-heads, showing the respective positions of the uncoupled and coupled pins *a a*. In the former, the left of the figure, the pin *a* rests on a sliding latch, which will give way before the thrust of the link *d*,— a result already accomplished in *H'*, the right-hand figure.

I I' are two matching draw-heads, corresponding in essential respects with the one just described; sliding pistons holding up the link and retiring before the thrust of the entering link.

Fig. 1108.



Car-Couplings.

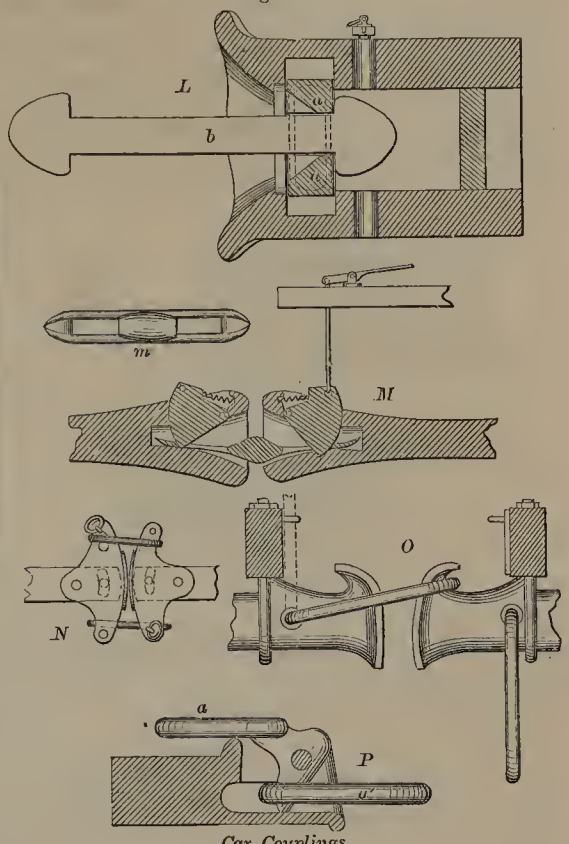
J has a double feature. A plate to hold the projecting link *a* in coupling position, and a small sliding-latch *b* above, to hold the coupling-pin *c*, which is dropped, when the draw-heads come into actual collision and thrust in the latch.

K has a ball *a*, which holds up the pin, and rolls away before the thrust of the link *b*, allowing the pin to drop.

In Fig. 1109 *L* has the arrow-head bolt *b*, which is a substitute for the usual link, and is grasped between the pair of jaws *a a*, which spring apart to receive it. The arrow-head form of coupling has many variations, which principally concern the modes of retention.

M has a bar with two slots instead of two heads, the bar being shown separately at *m*. As the end of the bar *m* enters the draw-head, it thrusts up the gravitating-latch, which immediately falls into the slot of the bar. To uncouple the link, the latch is lifted by a lever above.

Fig. 1109.



Car-Couplings.

N is a plan view of a coupling in which each draw-head has a link which couples over a horn on the corresponding draw-head of the other car. A pin in each case prevents accidental disengagement.

O is an elevation of a pair of draw-heads, each of which has a link which may be coupled over a horn on the other.

P has a two-horned tumbler, one of which carries a link *a* which may be the means of coupling to a corresponding draw-head, and the other forms a latch for a link *a'* proceeding from the other draw-head.

KENDALL'S English patent, April 17, 1841, describes an elastic coupling which retains its hold while the pull is direct, and becomes detached when the pull is oblique, by reason of one of the carriages leaving the track. This feature has formed the subject of many United States patents.

Card. 1. (*Cotton and Wool Manufacture.*) *a.* An instrument for combing wool, flax, or cotton, to disentangle or tear apart the tussocks and lay the fibers parallel in order for spinning.

The work is analogous in some of its effects to that of hackling, in which flax for the distaff is brought into a condition for being drawn out by the hand, in the old modes of spinning. With cards and in the carding-machine shorter fiber is operated upon than in the case of hemp or long flax, of which a hank is taken and switched down upon the teeth of the hackle.

A *card* is a wire brush in which the teeth are inserted obliquely through a piece of leather, or of cotton, linen, or india-rubber, which is then nailed to a wooden back.

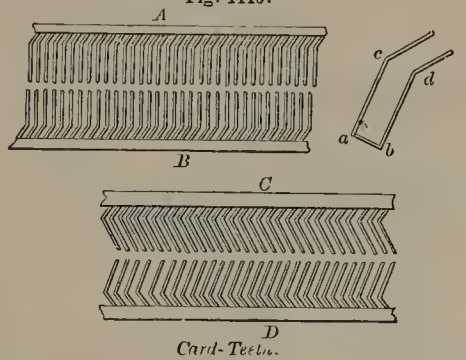
With hand-cards, they were operated by drawing them past each other, so as to disentangle the bunches of fiber and lay the filaments straight. A similar effect is produced in the carding-machine (which see), but the opposing cards are upon a large re-

volving-cylinder, and a number of circumjacent wire rollers and flat cards.

The leather or other material to be furnished with *teeth* is pierced with numerous holes, in which are fixed bent pieces of hard drawn wire called *dents* or *teeth*.

Each piece is first bent at right angles at *a* and *b*, and afterwards a second bend at *c d*, at an obtuse angle, which must be invariable for the same set of

Fig. 1110.



Card-Teeth.

cards. Strict uniformity is necessary as to the size, shape, obliquity, and length of the teeth, and also in the angle which they bear to the cylindrical surface around which they are placed.

The action of the cards is as follows: —

If the two cards *A* and *B* be moved in opposite directions with a tangled tuft of cotton-wool between them, the fibers will be seized by all the teeth, one card pulling them one way and the other pulling them the other, until, by repeated applications of the cards, the fibers are disentangled and laid in parallel lines, each card taking up and retaining a portion of the cotton. All the cotton may be gathered on one card by reversing the position of the two and placing them as when, by drawing the upper card *C* over the lower one *D*, the teeth of the lower one offer no resistance, but give up their cotton to the upper card.

Just as by the persistence of application of the hand-card the bunch of cotton is at last reduced to order, so in the carding-machine the operation is repeated between a central carded cylinder, and several carded rollers and flat cards, so arranged as to return imperfectly reduced knots again and again to the main cylinder. See CARDING-MACHINE.

Cards are distinguished by quality, the form of the backing, or position; as, —

Sheet-card or *card-sheet*.

Fillet-card, in form of a ribbon.

Breaking-card. *Finishing-card*.

Top-card; top-flat.

b. A *sliver* of fiber from a carding-machine.

Cardings or *rolls* are delivered of the length of the card-roller, the *clothing* on which is in longitudinal strips. See ROLLER-BOWL; CARDING.

2. (*Menage*.) A currying-tool formed of a piece of card-clothing mounted on a back with a handle, and used as a substitute for a curry-comb.

3. (*Weaving*.) One of the perforated pasteboards or sheet-metal plates in the Jacquard attachment to looms for weaving figured fabrics. Each perforation represents a warp-thread which is to be lifted, and there are as many cards as there are weft-theads in a single occurrence of the pattern. The cards are presented consecutively by a revolving perforated bar. See JACQUARD LOOM.

4. (*Nautical*.) (From *cardinal*.) The dial or face of the mariner's compass, in which the needle and dial rotate together.

"Reason the card, but passion is the gale." — POPE.

It is marked with the compass-points. These points or rhumbs are 32 in number; the angle comprehended between two points is 11° 15′.

5. A pasteboard. A thick paper sheet made up of several layers.

6. A pasteboard cut to a size and marked for a game. The playing-cards are in four suits of thirteen each.

Cards are colored by stenciling, an art older in Europe than that of printing by relief-blocks. The common cards of one color, red or black, are called *pips;* the court cards, of many colors, are *têtes*. The art of stenciling as a mode of laying out ornamental designs for carving, frescoing, and repetitive ornamentation is very ancient.

Chatto, in his "Origin and History of Playing-Cards," London, 1848, says that the earliest playing-cards which he has had an opportunity of examining were evidently stenciled, and of the date of 1440. Stenciling cards was quite a business at Nuremberg, 1433–77, as appears by the town books. Chatto regards cards as an Eastern invention, and supposes that they became known in Europe as a popular game between 1360 and 1390. Covelluzzo, an Italian chronicler of the fifteenth century, says they were brought to Viterbo in 1379. Charles VI. used them 1393, and thereafter laws and commercial notices and restrictions give evidence that they were very common.

"There is a great deal of time lost in playing cards," said a moralizing gentleman. "Yes," said a lady devotee, "in shuffling and cutting. But then, how is it to be avoided?" Lady Spencer may have been one of the parties conversing, and Mark Isambard Brunel, the philosopher, another. This talented mechanician, at all events, did invent a machine for shuffling and cutting playing-cards without the aid of the fingers, and did so at a playful request of Lady Spencer.

Mr. Brunel's talent was most versatile. He constructed the Thames Tunnel; the block-making machinery of the Portsmouth (England) Dockyard; a theater in New York; a canal in New York State; the harbor defenses of New York; veneer-saws; shoe-making machinery; nail-making machines; paper-ruling machines; machines for twisting, measuring, and forming sewing-cotton into hanks; a hydraulic packing-press; improvements in suspension bridges, building arches without centering, steamboats, gas-engines, etc. His son, Isambard Kingdom Brunel, was the engineer of the Great Western Railway, of England, and the designer of the Great Eastern steam-ship.

Cards are interesting in the history of the arts as being among the earliest subjects of the printing process. See PRINTING.

With the games this work has nothing to do, and perhaps, but for M. I. Brunel, the subject would not have been referred to here.

A good article on the subject of cards and dice may be consulted in Harper's Magazine, Vol. XXVI., pp. 163–176.

Card'board. Cardboard is produced by pasting a number of sheets of paper together. Bristol board is all white paper, and is made of two or more sheets according to the thickness required. Other qualities are made by inclosing common thick paper between sheets of white or colored papers of the required quality.

A surface of paste is given between the contacting surfaces of the outside paper and the filling, and a pack of pasted *boards* are subjected to a heavy press-

ure, which squeezes out the water. The cardboards are then hung up in pairs to dry, and in 24 hours are ready for the press, which renders them perfectly smooth and polished.

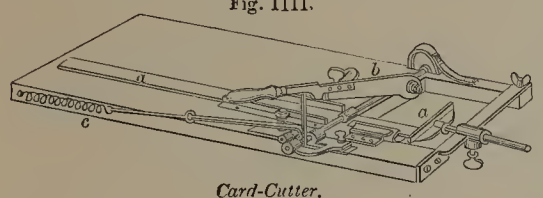
The cardboards are made up into a pack alternately with polished copper plates, and the pack is passed between a pair of rolls under heavy pressure. This removes all inequalities, wrinkles, and protuberances, the result being a highly polished glazed surface.

Card'board-press. A press having a pair of rolls adapted to be closed together with great force, and used to smooth and polish sheets of card passed there-through.

Card-cloth'ing. The garniture of a carding-machine.

Card-cut'ter. A machine for reducing cardboard to pieces of uniform and proper size for cards.

Fig. 1111.

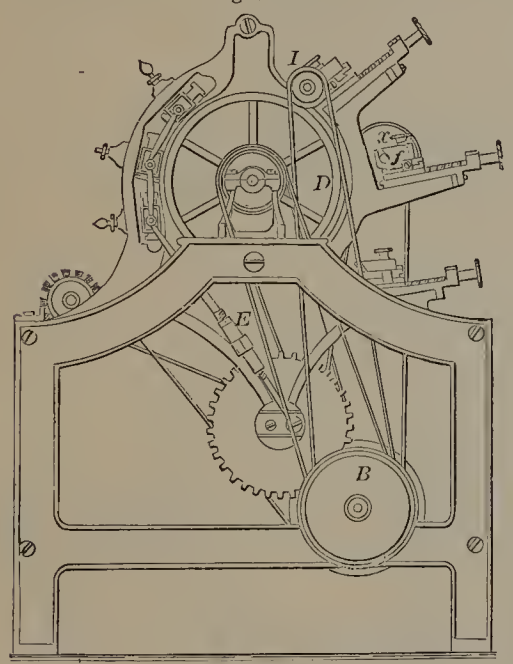


Card-Cutter.

In that shown, the paper is held by the adjustable gage-clamp *a*, and is cut by the knife *b*, which is elevated by the spring *c* and connections, and depressed by hand.

Card Grind'ing-ma-chine'. A machine having a rotary emery-wheel *D* revolving in a central position relatively to the *flats* and card cylinders, which are arranged around it. The grinding emery-wheel has longitudinal reciprocation on its slotted

Fig 1112.



Card-Grinder.

shaft by an inclosed screw therein, and grinds simultaneously two or more top flats and two or more *workers*, *strippers*, or *licker-in* cylinders. Each top flat reciprocates in a guide tangential to the wheel by a connecting-rod *E* to a crank-pin. The bearings *f* for the ends of the flats and of the cylinders, as at *x*, are adjustable radially to the grinding-shaft. The cylinders are rotated on their axes by bands from pulley *B* on the lower shaft, reaching to the pulleys on the cylinder-shafts, as at *I*.

Card'ing. A roll of wool as it comes from the carding-machine. The *doffing-cylinder* has longitudinal bands of cards, the wool on which is removed by the *doffing-knife* in the form of separate *slivers*, the length of the doffing-cylinder. These slivers fall into a *roller-bowl*, which gives them a slight rolling and compacts them into *cardings*. These have but little strength, as their fibers are only held together by being interlaced. They next receive a slight twist in the *slubbing-machine*.

Card'ing-ma-chine'. (*Fiber.*) A machine consisting of a congeries of toothed cylinders for drawing out and placing in parallel line the fibers of wool, cotton, or other staple.

The hand-card, which preceded the carding-machine, consisted of two brushes furnished with short, slanting, wire teeth, which all pointed in one direction. The wires were passed through leather, and the leather was nailed to a board. The brushes were grasped, one in each hand, and drawn past each other, so laying straight the fiber which was placed between them. The action is explained under CARD (which see).

In 1748, Lewis Paul patented two different machines for carding. In one of them the cards are arranged on a flat surface, and in the other they are arranged on the periphery of a drum. From what cause we know not, the invention seemed to have no repute or success at the time, but came out again twelve years afterward as the invention of Hargreaves, under the auspices of Robert Peel, of Bamber Bridge, the grandfather of the statesman, Sir Robert Peel. Hargreaves fixed one of the cards in a block of wood, and the other was slung from hooks fixed in a beam. The hooks remained in the kitchen at "Peel Fold" in 1850, but the cards were destroyed by a mob who came from Blackburn,—a part of the same wretched story of ignorant men opposing the introduction of machinery.

The same Robert Peel, or his son of the same name and the father of the statesman, employed Hargreaves in 1762 to erect the cylinder carding-machines in a mill at Blackburn.

Though the carding-machine was well and efficiently constructed in the time of Arkwright, it was not till after several attempts by different men, Paul, Hargreaves, and Arkwright, worked in such a manner that it is difficult now to determine what share each had in the matter. It was not till twenty years after Paul's invention that the cylinder carding-machine came into extensive use; and even then it performed intermittingly, and did not yield a continuous sliver.

The cards were arranged on the surface of the drum, parallel to its axis, a space being left between each. The cotton-wool was put on by hand, and when the cards were full the machine was stopped, the cardings taken off separately by a movable comb, the spaces between the cards regulating the substance of each carding. The cardings were then joined end to end, to make a continuous sliver. A more systematic and equable mode of feeding was adopted when a weighed quantity of cotton was made to cover a certain area of the travelling feed-apron, which moved at an even rate towards the throat of the machine.

Arkwright invented the plan, yet in use in some cases, of rolling up the feeder with the cotton spread upon it, and allowing it gradually to unroll to feed the cylinder.

Another improvement was to obtain a continuous

sliver from the cylinder. This was accomplished by the *doffer*, but the next point was to get it from the *doffer*. After many experiments, it appears that Arkwright hit upon the plan which is in use to the present time, the *crank* and *comb*. It is fair to say, however, that the invention is also claimed for Hargreaves. There seems to have been a rivalry of feeling between the two men, who were each highly meritorious, and we are much indebted to both. It is stated that Hargreaves obtained a sketch of it from one of Arkwright's men. Not likely; Hargreaves seems to have been made of better stuff.

The comb is a plate of metal toothed at the edge, and, reciprocating perpendicularly, detached the fleece from the teeth by slight reiterated strokes.

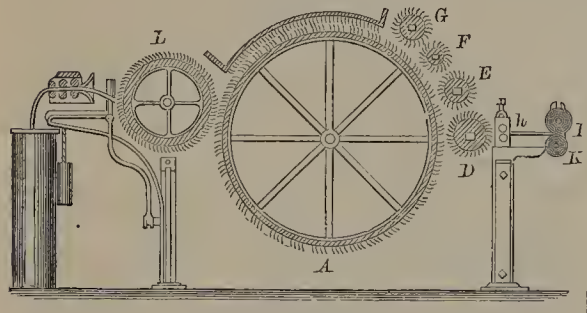
The action of the machine is substantially similar to that of the hand-cards, so far as the functional character is concerned; but it enables a number of cards to act upon a continuous *lap* and deliver continuous *slivers*.

The machine has a horizontal cylinder, whose entire circumference is covered with narrow fillet-cards wound spirally around it, a blank space intervening between each fillet, or is covered with strips lengthwise of the cylinder. The cylinder revolves beneath a concave shell, whose face is also lined with cards, and the teeth of each act coincidently upon the bunches of fiber to draw them apart and lay the individual fibers parallel, as explained under CARD.

The first carding-machines built in America were made for Mr. Orr, of East Bridgewater, Mass., in 1786.

The carding-machine consists of a number of rollers and drums, and one large cylinder all clothed

Fig. 1113.



Carding-Machine.

with *cards*, which are so arranged as to feed, card, doff, and deliver. A portion of the circumference of the large cylinder *A* is inclosed by smaller toothed rollers *D E F G*; then succeed wooden slats lying lengthwise of the cylinder, and supported by the side at such distance as to allow the wire teeth to come into the required proximity. These slats are called *card-tops*, *top-cards*, or *top-flats*. Beyond the flats is a toothed drum *L*, called a *doffer*, from whence the fleece is removed by the *doffing-knife*; the wide ribbon is then gathered in a thimble, consolidated by iron rollers, and delivered into a can.

The operation is as follows: —

The lap-cylinder is placed in the bearings *I*, and rests on the roller *K*; the end *h* of the lap is brought to the rollers by which it is presented to the toothed drum *D*, which draws the cotton into the machine, and is called the *licker-in*. The filaments thus torn from the end of the lap are immediately seized by the large cylinder *A*, which revolves at a much higher speed, and are teased out by the teeth of the second roller *E*, which moves more slowly than *D*, and picks the knots off the cylinder. These knots are carried round by *E* and are caught by *D*, which presents them again to *E* along with fresh material from the lap. This is the first round which the knots take, but several more are in store for them if they are obdurate or if they escape the first attack.

The tufts or knots which pass the first pair of rollers *D E* are arrested by the fourth roller *G*, which is placed closer to the cylinder *A*, and moves with the same speed as *E*. The knots caught by *G* are teased out by *F*, and returned to the cylinder *A*, and may be again caught by *G*, if they exist.

Passing the combination of rollers, the fibers are next brought into contact with the cards of the *top flats*, which arrest knots and hold them till the entanglement is removed, or till the flat is taken out and cleaned, which is occasionally done.

After all these obstacles have been passed, the filaments lie in parallel rows among the teeth of the cylinder card, and are removed therefrom by the *doffer L*, which is covered with a spiral fillet of cards, revolving at a much slower rate than the cylinder and in a different direction. The fine fleece thus stripped from the cylinder by the *doffer* is removed from the latter by a vertically reciprocating comb, called the *doffer-knife*, which has a rapid vertical motion tangentially to the points of the teeth. A fine fleece the whole length of the cylinder is thus obtained, and is gathered up into a ribbon, and passed in at the funnel, whence it passes to three consecutive pairs of condensing rollers, which, revolving at a relatively greater velocity as the sliver proceeds, slightly draw it, and tend to parallelize the fibers. It thence passes as a light, downy, coherent sliver into the can, in which it is transported to the *throstle*, *doubler*, or *bobbin and fly frame*, as the case may be.

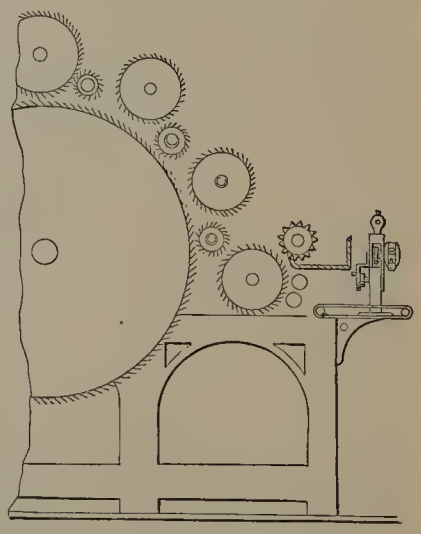
For fine spinning, the operation is repeated, the first machine being called a *breaker-card* and the second a *finishing-card*.

For the preparation of fine yarns, the cards have closer set wires than is necessary for ordinary or coarse work.

The carding-machine as just described is particularly adapted for cotton, but does not differ materially from the wool-carding machine.

There are some adjuncts to the latter, however, which have no place in the cotton-carding machines. Among these are the devices for oiling wool, which is necessary to keep the fibers loose and prevent their becoming felted.

Fig. 1114.



Wool-Oiling Attachment.

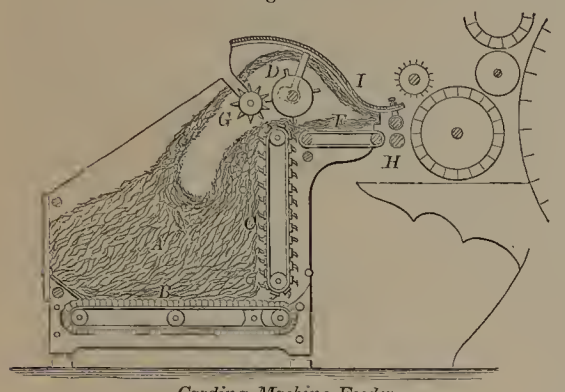
The *wool-oiling machinery for carding-machines* has a dripping oil-tank which has a transverse and rotary motion above the feed-apron of the machine, so as to drop oil upon the wool as it proceeds towards the card.

The transverse motion is given by a crank and pitman, and the reciprocating rotary by a toothed wheel acting against the edge of the trough.

The wool carding-machine has a large cylinder surmounted by smaller ones called *urchins*, which work in pairs, and are called *workers* and *cleaners*. These act in succession to remove knots and tangles from the main drum, and return the fiber to the latter again to undergo the action of the next set, if still obdurate.

In the feeder shown in Fig. 1115, the material thrown into the box *A* is carried forward and upward by the aprons *B C F* to the feed-rolls *H*. *G* is a

Fig. 1115.



Carding-Machine Feeder.

picker-roll, which serves to prevent the fan *D* from becoming fouled, and also to prevent flocks of wool from passing unopened between the plate *I* and apron *F*. The fan *D* blows the wool into the passage *F*, whence it passes to the carding-machine.

The various rollers in a carding-machine are known by names which indicate their functions, — or perhaps we may say appearance, in one case.

Feeding-rollers.	Urchins.
Distributing-rollers.	Clearers.
Workers.	Doffers.
Strippers.	Fly-rollers.

The material which went in as a *lap* comes out as a *fleece* or as *slivers*.

Car'do. A pivot and socket; an apparatus by means of which the doors of the ancients were fixed in their places, and made to revolve in opening and shutting.

Car-door Lock. For railway-cars; one with a latch opened by a key from either side.

Card-press. (*Printing.*) A small press adapted for printing cards, etc. A preferred form has an inclined bed, for convenience of feeding; the impression is given by a cam, and is regulated by means of platen screws. The press has adjustable feed-guides, a large distributing-cylinder, two inking-rollers, a card rack and receiver, and is capable of making from 1,000 to 2,000 impressions per hour.

Card-set'ting Ma-chine'. A machine for setting the bent wire teeth (*dents*) in the bands or fillets of leather, or alternate layers of cotton, linen, and india-rubber, which form the backing of the wire brush of the carding-machine.

For the card-setting machine the leather is first prepared by a planing-machine, which cuts it into fillets, which are then stretched and pared to an even thickness. This is wound upon a roller and fed to the machine, where it is held by a clamp while the wires are inserted. These are contained in a drum at the side. Two prickers advance and make holes through the leather; a pair of sliding pinchers seize the wire, and wind off from the drum a length sufficient for a tooth; a steel tongue holds this piece by the middle while it is cut off. Steel fingers bend it, and carry it forward to the holes made by the prickers. Pinchers on the opposite side of the leather seize the wires, and a bar rises up and bends the two limbs so as to form a knee in each. A pusher at the back then sinks the bight of the wire into the leather, which is then shifted by the guide-rollers, and the process is repeated. The cards are finished and made true by grinding. (See CARD-GRINDING MACHINE.) These wire brushes are termed cards, and such fillets form the *clothing* of the drums, cylinders, or strips to which they are fastened.

Ca-reen'ing. (*Nautical.*) The operation of exposing a part of a ship's bottom by a purchase applied to the masts to tilt them laterally from the perpendicular. It was careening that upset the "Royal George" in 1782 at Spithead: —

> . . . . "They
> Had made the vessel heel,
> And laid her on her side."

Ca'ret. (*Printing.*) A mark ("∧") indicating an insertion; interlinear or marginal.

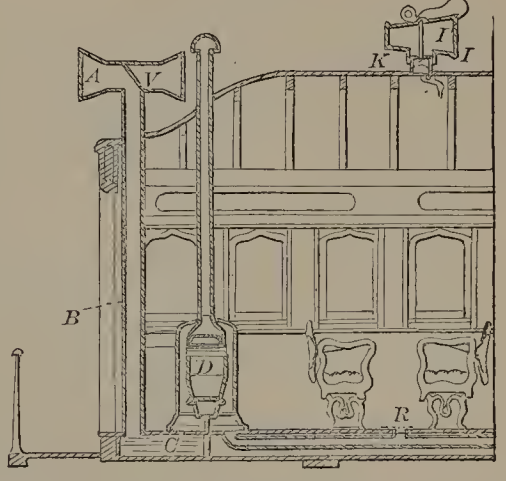
Car'go-jack. (*Nautical.*) An implement like a lifting-jack, but sometimes used upon its side for stowing heavy cargo.

Car'go-port. (*Nautical.*) An opening in the side of vessels having two or more decks, through which the lading is received and delivered. It is closed by a shutter; and made water-tight before proceeding to sea.

Car-heat'er. An arrangement for warming a railway-car. A stove or a system of pipes from one heater, which communicates in turn with each of the cars in the train.

In Fig. 1116 is shown the end of a car in which is a stove *D* inclosed in an air-heating chamber. *A* is a hood with a swinging valve *V*, the latter being placed in such position as to direct the air downward by pipe *B* in whichever way the car may be moving.

Fig. 1116.



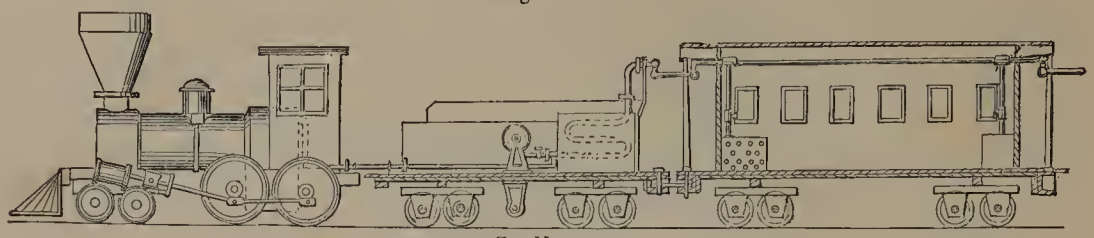
Car-Heater.

The air, on its way down, is washed in the cistern *C*, and, after heating in the chamber around the stove, is conducted by pipes beneath the floor, and escapes at registers *R* into the saloon. The outward current is induced by an adjustable cowl *I I K*, which is set with its flaring mouth towards the rear of the car for the time being.

Fig. 1117 shows an arrangement in which the cars of the train are heated by steam from the locomotive, or by heated air; pipe-couplings between the cars being the means of connecting the system of pipes and radiators of the respective cars.

When the cars are in motion, the steam-pipe is

Fig. 1117.



Car-Heater.

closed, or nearly so, and the fan set in operation to force air through the furnace-pipe and register into the different cars. The air may be moistened by the admission of a small amount of steam. In case of a detention of the cars, the air-pipe near the fan is closed by a valve, the other air-valves are closed, and, the steam-valve being opened, steam is forced through the coil in the heater and into the radiators.

Another form for heating street-cars is a stove beneath the bed and registers in the floor, or hot-air distributing-pipes throughout the car.

Car'il-lon. (*Music.*) A chime of bells, originally consisting of four, and played by keys. See CHIME.

One form of carillon machinery has barrels with pins, which first effect the elevation of the hammer and then deliver the blow; but, by an improvement, the work of the pins is confined to releasing detents and causing the hammer to strike the bell, simultaneously throwing forward a spring finger in the path of peculiar cam-wheels, continuously revolving, which thereby immediately elevate the hammer again into the striking position.

Car-in'di-ca'tor. A registering device operated by a revolving wheel or axle of the car, to indicate the distance run. In one case, the indicator is operated partly by clock-work and partly by the revolving wheel or axle of the street-railway car to which it is applied. It determines at the end of a trip whether the car has been running regularly, and, if not, at what points on the road improper stoppages have been made, or where the speed of the car has been increased or retarded.

Car'i-ole. (*Vehicle.*) *a.* A small, open carriage.

b. A covered cart.

c. A kind of calash.

Car-jack. (*Railway.*) A powerful form of screw-jack by which a car or locomotive is lifted, to replace it on the track, to run a truck beneath, or for other purpose in the shop or on the road.

The hydraulic-jack is the more efficient implement, and is now made in very compact, portable, and powerful form. See HYDRAULIC-JACK.

Car-lamp. One for lighting the inside of a railway-car at night or in tunnels. Candles are frequently employed in the place of oil, to avoid the danger of adding fire to the other disasters in case of the overturning of the car.

In street cars the lamps are frequently made to illuminate a sign, which indicates to pedestrians the destination of the car; or a colored glass may indicate to habitual patrons the same thing.

Car-lan'tern. One adapted to be carried on the arm, to leave both hands free. See LANTERN.

A signal-lamp indicating destination, raised above the roof of the car.

Car'let. A three-square, *single-cut* file, or *float*, used by comb-makers. See COMB.

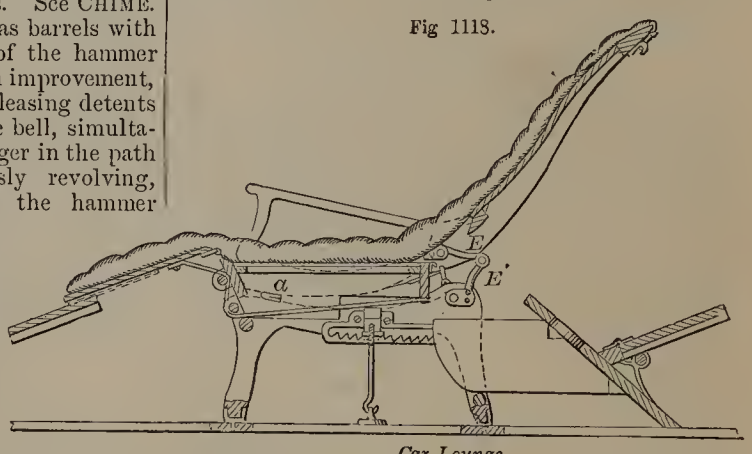
Car'ling. (*Shipbuilding.*) One of the longitudinal beams which are framed into the transverse deck-beams and aid in trussing the frame of the ship.

The *coamings* of a hatchway are bolted to the top of the *carlings*, and the *head-ledges* to the top of the *beams*.

Car'ling-knee. (*Shipbuilding.*) A knee in a ship lying across from the sides to the hatchway beneath the deck.

Car-lounge. A car-seat or sleeping-chair, so contrived as to assume a reclining position when desired. The illustration shows the lounge of one passenger and the foot-rest of the person immediately

Fig 1118.



Car-Lounge.

behind him. The body of the seat is hinged at *a* to the frame, and the more or less reclining position is obtained by means of the knuckle-joint *E E'*. The foot-rest is an extension piece, which is projected when needed; the motions of the back and leg-rest are coincident.

Ca-roche'. (*Vehicle.*) A kind of two-wheeled pleasure-carriage.

Car'ol. (*Building.*) A seat fitted within the opening for a window; a *bay-stall*. *Caroll; carrol.*

Car'pen-ter's Chis'el. Chisels for wood-workers' use are made of moderately hard steel, have one plane and one beveled edge, and are divided into *firmer* and *framing* or mortise chisels.

The former have a tang inserted into the handle, the lower end of which rests against a flange on the stem, while in some of the latter the handle is inserted into a socket at the upper part of the stem.

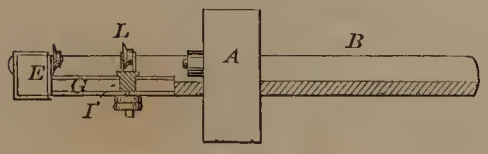
Joiner's and *paring* chisels are names of grades, rather than of kinds. See CHISEL.

Car'pen-ter's Clamp. A frame in which work such as doors, sashes, shutters, etc., is forced up into place, and held while being nailed or pinned.

A kind of vise for grasping several parts and holding them while the glue sets, or for other purposes.

Car'pen-ter's Gage. A scribing-tool for depth or width, according to construction and uses. It commonly has a point projecting from the shank *B*, and a movable head or fence *A*, which is adjusted for distance from the point, and secured by a set-

Fig. 1119



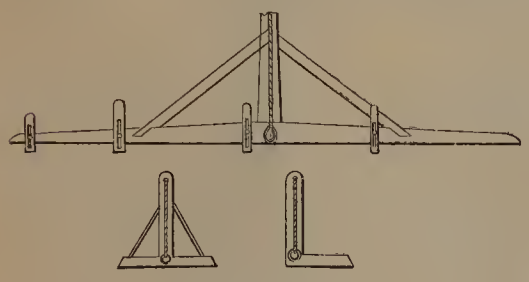
Carpenter's Gage.

screw. In the example, revolving rollers with sharp edges are used instead of marking points, and the roller L is adjustable towards and from the roller E for making two parallel scribes at a determinate distance from the fence A.

Car'pen-ter's Lev'el. An implement for determining horizontality and verticality.

It has a base piece, standard, and plumb-line, and

Fig 1120.



Carpenter's Levels.

is used by builders and road-makers in testing surfaces, to ascertain whether they are level.

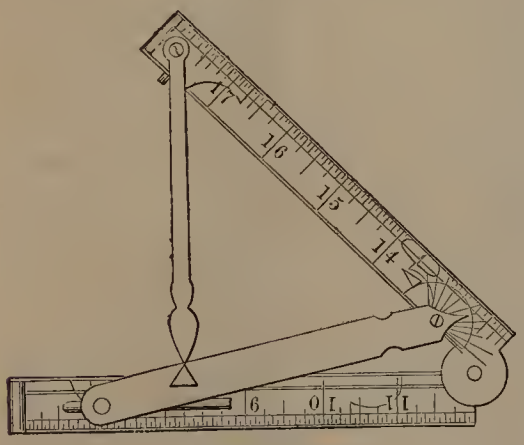
The feet may be so adjusted, to suit the required grade or pitch, that the level becomes a means of determining a slope.

Car'pen-ter's Plane. Carpenter's planes are of various descriptions, adapted to the different kinds of work they are intended to perform, — as, the jack-plane, for rough-dressing a surface; the smoothing-plane, for finishing it off; and grooving and molding planes, some of which have special names, for making grooves or elevations of various forms. See PLANE.

Car'pen-ter's Plow. A plane for making a groove in the edge of a board, to be occupied by the matching tongue of another board, or by the edge of a panel.

Car'pen-ter's Rule. Ordinarily, a two-foot rule, jointed in the middle and divided to eighths or sixteenths of an inch.

Fig. 1121.



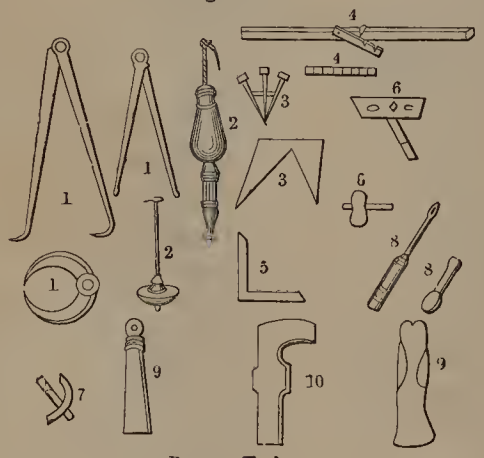
Carpenter's Rule.

That shown in the figure has a pointed swinging arm, and also a curved scale and pointed index, so that the instrument may serve the purposes of a level, square, and bevel, any angle of inclination being noted by the pointer upon said scale.

Car'pen-ter's Square. An L-shaped steel rule having two arms meeting at a right angle, and graduated to feet, inches, and fractions. It is used by carpenters and other mechanics for laying off perpendiculars to a line or surface, and setting off the distances thereon at the same time. See TRY-SQUARE.

Car'pen-ter's Tools. In the reign of Henry II. of England, the whole stock of a carpenter's

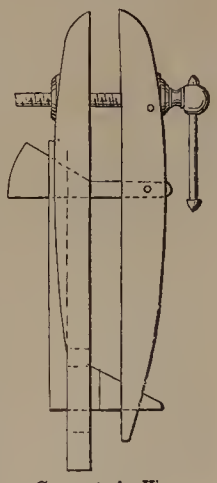
Fig. 1122.



Roman Tools.

tools was valued at one shilling, and consisted of a broadaxe, an adze, a square, and a spoke-shave. The number has largely increased since. See specific index, WOODWORKING.

Fig. 1123.



Carpenter's Vise.

Fig. 1122 shows a variety of old Roman implements of this kind, as represented on existing monuments.

1 1 1, compasses and calipers.
2 2, plumb-bobs.
3 3 5, templet and squares.
4 4, single and jointed rules.
6 6, mallets.
7, adze.
8 8, scriber and soldering-tool.
9 9, chisels.
10, hatchet.

Car'pen-ter's Vise. A device with a stationary jaw attached to the bench, and a movable jaw operated by a screw, used for clamping a board or timber while being operated on by the plane or chisel.

Car'pen-try. See under the following heads:—

Abat-jour.
Abat-voix.
Abutment.
Accouplement.
Ajambe.
Ambe.
Angle-bar.
Angle-tier.
Ante-venno.
Apron.
Apron-piece.
Arched-beam roof.
Architrave.
Arris.
Arris-fillet.
Arris-gutter.
Ashlering.
Astragal.
Attic.
Awning.
Badigeon.
Balk.
Baluster.
Barge-board.

Barge-couple.
Base.
Batten.
Bay.
Bead.
Bead and butt work.
Bead and quirk.
Bead, butt, and square work.
Beaking-joint.
Beam.
Bearer.
Beneh-vise.
Bent.
Bevel.
Binder.
Binding-joist.
Binding-rafter.
Bird's-mouth.
Blind.
Bloeking.
Bolection.
Bolster.
Box-frame.
Box-girder.
Boxing.
Braee.
Bracket.
Breast-summer.
Bridge-board.
Bridging-joist.
Bridging-pieee.
Brob.
Brog.
Brow-post.
Built-beam.
Built-rib.
Butment-eheeks.
Button.
Cage.
Caisson.
Camber-beam.
Camp-eeiling.
Cantilever.
Careass.
Careass-roofing.
Carpenter's elamp.
Carpenter's square.
Carpenter's tools.
Carriage.
Carriage-pieee.
Cartoueh.
Case-bay.
Casemate.
Casement.
Cavetto.
Ceiling.
Ceiling-joist.
Chain-timber.
Chalk-line.
Chantlate.
Chevron-molding.
Clamp.
Clamp-serew.
Clapboard.
Cleading.
Clear-stuff.
Coak.
Coeket-eentering.
Cocking.
Coekle-stairs.
Coffer.
Collar-beam.
Compass-window.
Corbel.
Cornice.
Couples.
Coved-eeiling.
Cradle.
Crenelated molding.
Cribbing.
Cripple-timbers.
Cross-beam.
Crown-post.
Culver-tail.
Curb-beam.
Curb-plate.
Curb-roof.
Curtail-step.
Current.
Cushion-rafter.
Dado.
Dais.
Deadening.
Deal.
Dental cut.
Diagonal.
Dimension-lumber.
Dished-out.
Dog-leg stairs.
Dome.
Door.
Door-ease.
Door-step.
Door-strip.
Dorman-tree.
Dormer.
Dovetail.
Dragon-beam.
Draw-bore.
Dwarf-rafter.
Eave.
Eave-board.
Eave-trough.
Estrade.
False rail.
False roof.
Faying out.
Feather-edged.
Femerell.
Fender-beam.
Filling-in pieees.
Fishing.
Flap.
Flight.
Fliteh.
Floor.
Floor-elamp.
Fox-tail wedging.
Frame.
Franking.
Freneh-roof.
French-window.
Fret-work.
Fuor.
Furring.
Gable.
Gage.
Gain.
Gambrel-roof.
Garret.
Geometrie staircase.
Girder.
Grafting.
Ground-plate.
Grounds.
Ground-sill.
Gutter.
Half timbered.
Halving.
Hammer beam-roof.
Hand-rail.
Hatehet.
Heading-eourse.
Heading-joint.
Heel-post.
Herring-bone.
High roof.
Hip.
Hip-knob.
Hip-rafter.
Hip-roof.
Hoarding.
Hollow newel.
Housing.
Impages.
Inter-ties.
Interligneum.
Jack-timber.
Jalousie.
Jamb.
Jib-door.
Joggle-post.
Joist.
Jut-window.
Key.
King-post.
King-truss.
Knee.
Ladder.
Lagging.
Laminated-rib.
Landing.
Lath.
Lathing-elamp.
Lattiee.
Leaf.
Lean-to.
Ledge.
Ledger.
Level.
Line-winder.
Lining.
Lintel.
Listing.
Luffer (Louvre).
Lumber.
Main-couple.
Mallet.
Mansard-roof.
Match-boarding.
Mitered border.
Molding.
Mopboard.
Mortise.
M-roof.
Mud-sill.
Muntin.
Needle-beam.
Newel.
Nogging.
Norma.
Nosing.
Noteh-board.
Notehing.
Pale.
Panel.
Partition.
Piteh.
Pitehing-piece.
Plane.
Plugging.
Plumb.
Plummet.
Pole-plate.
Post.
Prick-post.
Prineipal.
Pugging.
Punch.
Puncheon.
Purlin.
Quarters.
Queen-post.
Quirk.
Rabbet.
Rafter.
Raising-plate.
Ramp.
Reason-pieee.
Reglet.
Relish.
Reveal.
Riser.
Roll and fillet.
Roof.
Rule.
Run.
Sarking.
Sash.
Sash-frame.
Scaffold.
Scaffold-bracket.
Scantling.
Scarf.
Scraper.
Scribe.
Severy.
Shaker.
Shutter.
Shutting-post.
Shear-legs.
Side-plane.
Shingle.
Shook.
Shooting-board.
Shore.
Side-plane.
Sill.
Sinking.
Skirting.
Skylight.
Slab.
Sleeper.
Soffit.
Sound boarding.
Span-roof.
Spliee.
Spring-beam.
Staging.
Stairease.
Stair.
Standard.
Sticking.
Stile.
Stirrup.
Stoek.
Story-post.
Story-rod.
Straining-beam.
Straining-sill.
Strap.
Striking-plate.
String-board.
Stringer.
Strut.

Stub-tenon.
Summer.
Sunk coak.
Sunk-panel ceiling.
Surbase.
Swing-beam.
Syphering.
Tabling.
Templet.
Tenon.
Tension-rod.
Tie.
Tie-beam.
Tilting-fillet.
Tongue.
Tools. Carpenter's and joiners (see WOODWORKING TOOLS)
Torsal.
Trap-door.
Trellis.
Trenail.
Trestle.
Trimmer.
Truncated roof.
Truss.
Trussed roof.
Turnpike-staircase.
Tusk.
Upright.
Venetians.
Veranda.
Wainscot.
Wall-plate.
Wane.
Wash-board.
Weather-boarding clamp.
Weather-boarding gage.
Weather-strip.
Well-staircase.
Wind-beam.
Window.

Car'pet. A cloth or rug to cover a floor.

The use of rugs is of great antiquity in Egypt, India, and China; later, those of Persia and Turkey have been the more celebrated. They were anciently spread upon the ground or floor, in the tents or in apartments, and in the Orient are still small, used for sitting or reclining upon, or beneath the couches; as the Sardinian carpets, mentioned by a Grecian poet,—"Beneath the ivory feet of purple-cushioned couches."

> "Phœnicia sends us dates across the billows,
> And Carthage, carpets rich, and well-stuffed pillows."
> HERMIPPUS, quoted by Athenæus (A. D. 220).

At the supper of Iphicrates, purple carpets were spread on the floor; and at the magnificent banquet of Ptolemy Philadelphus, an account of which is given by Callixenus of Rhodes, we learn that underneath 200 golden couches "were strewed purple carpets of the finest wool, with the carpet pattern on both sides; and there were handsomely embroidered rugs, very beautifully elaborated with figures. Besides this," he adds, "thin Persian cloths covered all the center space where the guests walked, having the most accurate representations of animals embroidered on them."

The Babylonians were very skillful in weaving cloths of divers colors; we read of "a goodly Babylonish garment" as long ago as the time of Joshua, B. C. 1451, as among the spoils of Ai. The Babylonish carpets had representations of human figures and composite animals, such as winged bulls with human heads, griffins and dragons. These were numbered among the luxuries of Heliogabalus. On the tomb of Cyrus was spread a purple Babylonian carpet, and another covered the bed whereon his body was placed. These carpets were exported in considerable quantities to Greece and Rome. Researches in Pompeii show that they were used in that city in the time of Imperial Rome.

Sir J. Gardner Wilkinson gives an account of one carpet rug of Egyptian manufacture. "It is made like many cloths of the present day, with woolen threads, on linen strings. In the center is the figure of a boy in white, with a goose above, the hieroglyphic of a 'child,' upon a green ground, around which is a border composed of red and blue lines." He also mentions some fine specimens of worked worsted upon linen, now in the Turin Museum, in which the linen threads of the weft have been picked out and colored worsted sewed on the warp. These are specimens of tapestry-weaving, and resemble the present work of Persia and Turkey. The tapestry consists of woolen threads sewed on the strings of the warp by means of small shuttle-needles. The Persian carpet is formed by knotting into the warp tuft after tuft of woolen yarn, over each row of which a woof-shot is passed, the fingers being here employed instead of the shuttle-needles, as the fabric is of a coarser description. Such carpets are formed in looms of very simple construction; the warp-threads are arranged in parallel order, whether upright or horizontal, and the fabric and pattern are produced by colored threads, hand-wrought upon the warp. This may be designated the hand-wrought or needlework method, which only makes one stitch or loop at a time, in contradistinction to the machine-wrought process, the result of mechanical appliances, whereby a thousand stitches are effected at once. Herein lies the essential difference between the ancient and modern, the simple and complex, carpet-manufacture.

In Persia there are entire tribes and families whose only occupation is that of carpet-weaving. These dispose of their productions at the bazars to native merchants, who remove them to Smyrna or Constantinople, where they meet with European purchasers. The trade in real Persian carpets is, however, very limited, owing to their small size. They are seldom larger than hearth-rugs, long and narrow. Felted carpets, or *nurmuds*, are also made in Persia, but are not considered worth exporting. One specimen of carpet from Persia had tufts of worsted inserted in a felt back.

Carpets are manufactured in many of the provinces of Asiatic Turkey. In none of these places, however, does any large manufactory exist; the carpets are the work of families and households. They are woven in one piece, and there is this notable peculiarity in their manufacture, that the same pattern is never again exactly reproduced; no two carpets are quite alike. The patterns are very remarkable, and their origin is unknown even to Mussulmans. The Turkey carpet pattern represents inlaid jeweled work, which accords with Eastern tales of jewels and diamonds.

In British India the carpet manufacture is carried on extensively. At Benares and Moorshedabad are produced velvet carpets with gold embroidery. A very elaborate carpet sent from Cashmere to the London exhibition by Maharajah Goolah Singh was composed entirely of silk, and excited great admiration. In every square foot of this carpet, we are informed, there were at least 10,000 ties or knots. Silk embroidered hookah carpets, cotton carpets, or *satrunjees*, printed cotton carpets, printed floorcloth, woolen carpets, are made in different districts of British India. Of late years, linen warp has been introduced instead of cotton, and the fabric is thereby much improved. The designs of the Indian carpets have more regularity than those of Turkey, and the colors are mostly warm negatives, enlivened with brilliant hues interspersed.

Carpets were introduced into England at the time of the Crusades.

In the times of Edward VI. and Elizabeth of England the floors of palaces were strewn *daily* with rushes. This frequent change of rushes was considered to betoken an effeminacy which augured but poorly for the stability of the dynasty and the ruling families.

The walls were hung with tapestry and cloths long before the floors were carpeted. In Hampton Court Palace, built by Cardinal Wolsey, the beautiful floors are yet bare and the walls covered with tapestry.

In the Middle Ages carpets were used before the high altar and in certain parts of the chapter.

Bedside carpets are noticed in 1301, and carpets for the royal thrones in the fifteenth century.

Turkey carpets before the communion-table were used in the reigns of Edward VI., Elizabeth, and the Stuarts.

The manufacture of carpets was introduced into France from Persia, in the reign of Henry IV., about 1606; a manufactory being established at Chaillot, near Paris.

Workmen from France introduced carpet-making into England about 1750. A carpet-factory was established at Axminster, 1755, the year of the Lisbon earthquake.

There are several characteristic processes in the manufacture of carpets.

1. The web is formed of a warp and weft of flax, and the wool or worsted is inserted in tufts which are twisted around each of the warp-threads, the color of the tuft being determined by its position in the pattern. The tufts are locked in position by a shoot of the weft, the crossing of the warp, and the beating of the batten or lathe. The *Persian*, *Turkey*, and *Axminster* carpets are thus formed.

2. The web is formed of a warp and weft, as stated above, and the colored worsted yarns are laid along with the linen warp, and drawn into loops which project above the surface. Each yarn passes through an eyelet which depends from a cord, whereby it is drawn up to form a loop at the point where its color is required. This is the *Body-Brussels carpet*. They are usually 27 inches wide, with two threads of linen for the shoot, one above and the other below the worsted.

When the loops thus made are cut to form a nap, the carpet is known as a *pile* or *Wilton carpet*.

3. Tapestry Brussels differs from regular or body Brussels in being woven in a common loom and printed in the warp.

4. Tapestry velvet or patent velvet differs only from tapestry in being cut like Wilton.

5. The carpet is formed by an amplification of the ordinary weaving-processes; two or three webs being woven at the same time, the warps being interchangeable and being brought to the surface according to the color required, and forming two-ply carpet or three-ply carpet, respectively. The carpet is woven by a *figure-work* or ordinary loom, with some peculiarities, such as the exposure of the weft (*Ingrain*), the warp (*Venetian*), or a peculiar weft (*Chenille*).

6. The carpet is formed of a body of fibers felted together with a fabric without spinning or weaving. The product is generally printed, and forms *drugget*.

7. The carpet is woven in plain colors and afterwards printed.

8. The carpet is dyed in party-colors, nicely adjusted so as to fall into their right places when woven into a fabric.

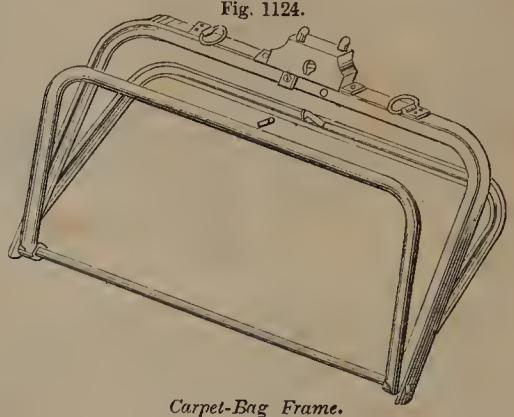
9. A pile is cemented to a backing-fabric. See CEMENTED-BACK CARPET.

For the varieties of carpets see the following: —

Axminster carpet.	Ingrain carpet.
Brussels carpet.	Kidderminster carpet.
Cemented-back carpet.	Persian carpet.
Chenille carpet.	Pile carpet.
Damask carpet.	Printed carpet.
Drugget.	Rag carpet.
Felt carpet.	Rug.
Scotch carpet.	Two-ply carpet.
Tapestry carpet.	Velvet-pile carpet.
Three-ply carpet.	Venetian carpet.
Triple-ingrain carpet.	Wilton carpet.
Turkey carpet.	

Car'pet-bag Frame. The iron frame which distends the cloth covering of a traveling-bag or satchel. The two jaws are pivoted to the hinge-rod

Fig. 1124.

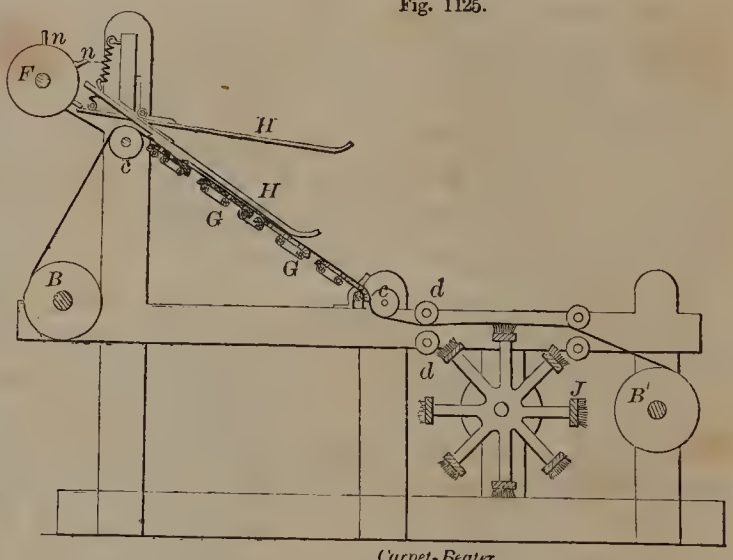


Carpet-Bag Frame.

and shut beneath the cap-piece of the frame, which is I-shaped in cross-section. The varieties and shapes are numerous.

Car'pet-beat'er. A machine in which carpets are beaten and brushed. The breadth of carpet

Fig. 1125.

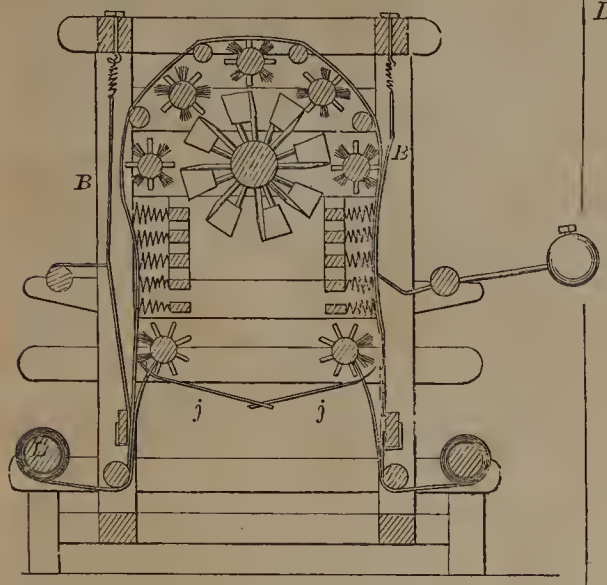


Carpet-Beater.

is wound on the roller *B*, passed over an inclined bed formed of a steam-coil *G G*, and subjected to the action of the beaters *H H*, which are tripped by the tappets *n n* on the wheel *F*. The carpet is stretched on the rollers *c c*, thence passes under *a*, is exposed to a revolving brush-cylinder *J*, and is rewound on the roller *B'*.

Car'pet-clean'ing Ma-chine'. A brushing-machine for carpets, which is unrolled from the beam *L'*, and re-rolled on the beam at the other side of the machine, passing on its way the various cleaning-devices. These are the cords *B*, which whip it on the outside; the canes *j*, which whip it on the inside; a succession of revolving brushes, which sweep it, and a revolving fan, which blows away the dust. (Fig. 1126.)

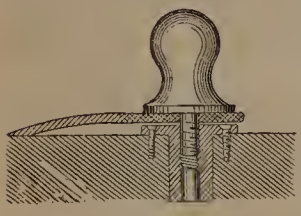
Fig. 1126.



Carpet-Cleaning Machine

Car'pet-fast'en-er. A screw-knob and screw-socket inserted in the floor with the carpet between them.

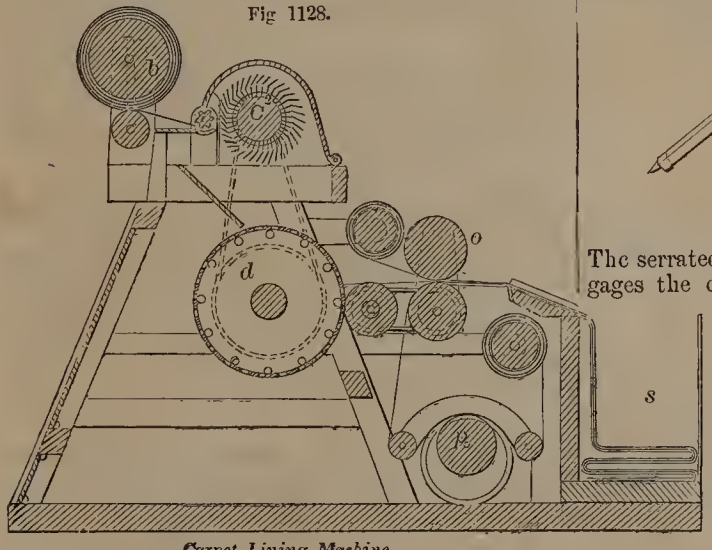
Fig. 1127.



Carpet-Fastener.

Car'pet-lin'ing. A material for placing beneath a carpet, to increase its elasticity and decrease the wear. It usually consists of a thickness of felt between two layers of paper, but there are many kinds. In the machine represented, the fibrous material from the roller *b* is formed into a fleecy mass by the carding-cylinder *C*, and collects

Fig 1128.

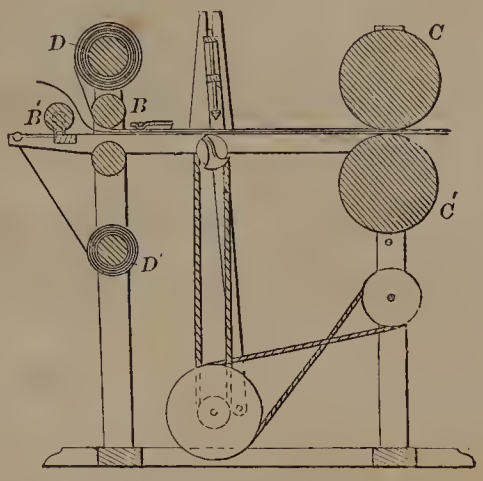


Carpet-Lining Machine.

the gauze as a bat on the gauze-covered cylinder *d*; a doffer takes it from this cylinder; it is caught between the thicknesses and pressed beneath the roller *o*. The lower sheet of paper is the wider, and is gummed on one surface by the gum-roller *R*; the edges of the wide strip are bent over the narrow one and stuck fast. The fabric is delivered into the box *s*.

In Fig. 1129 the paper is contained on two rolls *D D'*, and the webs are fed beneath the roller *B*,

Fig. 1129.



Carpet-Lining Machine.

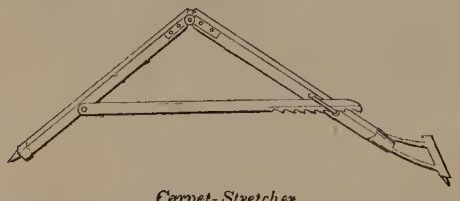
with an intervening thickness of felt shown as coming over the roller *B'*. From the smoothing-plate the fabric passes through a series of sewing-machines, by which it is quilted previously to passing between the measuring-rolls, and is pressed and delivered by rollers *C C'*.

Car'pet-loom. One for weaving carpets. See PILE-FABRIC; BRUSSELS-CARPET LOOM; JACQUARD, etc.

Car'pet-rag Loop'er. A stabbing-tool with a large eye, to carry one end of a carpet-strip through the end of the strip preceding, when one is looped over the other, to save the trouble of sewing.

Car'pet-stretch'er. A toggle-jointed frame to stretch carpets on floors preliminary to tacking down.

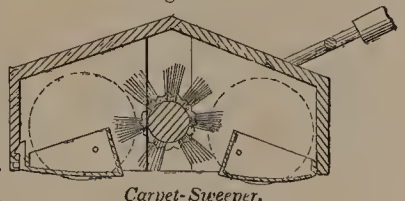
Fig. 1130.



Carpet-Stretcher.

The serrated bar at one end of the jointed staff engages the carpet, and the point at the other end extends through to the floor. A ratchet-bar is pivoted to one leg, and, passing through a staple upon the other, engages one side thereof, to keep the legs spread.

Fig. 1131.



Carpet-Sweeper.

Car'pet-sweep'er. A mechanical broom for sweeping carpets and collecting the dust and dirt in trays. The brush-shaft is rotated by a corrugated pulley driven by contact with the rubber periphery of one of the sustaining wheels.

Car-quaise'. (*Glass.*) The annealing arch of the plate-glass manufacture, heated by a fireplace called a *tisar*.

Car-reg'is-ter. (*Railway.*) A device for keeping account of all persons entering a car, so as to form a check on the receipt of fare by the conductor. It has various forms, none of which are in much favor.

1. A turnstile at the entering side of a platform, the revolutions being transmitted by a train of gearing to an indicator.

2. A similar train actuated by the opening of the door.

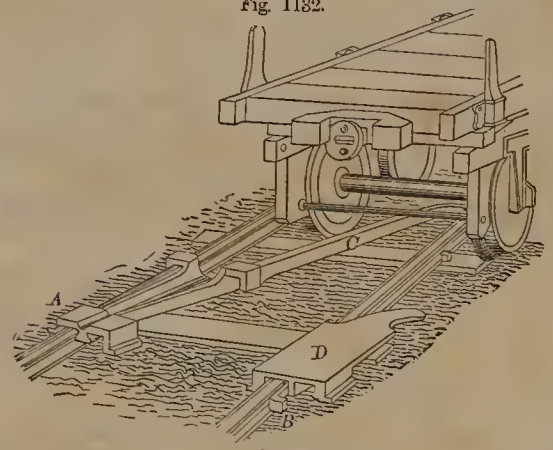
3. A train actuated by the pressure of the foot on a step at the mounting and entering side of the platform.

Car-re-plac'er. (*Railway.*) An instrument or means for restoring to the rails a car which has run off the track.

This operation is frequently accomplished by the jack-screw, aided by such things as handspikes and timbers which may be convenient. A full assortment belongs to the appendages of a "wrecking" car, whose use is to remove obstructions on the track, replace cars, and lift the *débris* of an accident on to the platform-cars, which bear them to the shop for repairs or for use as material.

A number of devices have been patented for the purpose of enabling a car to ascend to its position on the rails when drawn or driven by the locomotive. The general feature in which these agree consists of

Fig. 1132.



Car-Replacer.

two inclined planes, one forming a bridge with a plate *D*, to let the outer wheel cross the rail and drop into place; the grooved plate *A* forming a bridge up to the other rail. *C* is a bar to lead the wheel towards the bridge-piece.

Car'riage. 1. A wheeled vehicle especially for the conveyance of passengers. The vehicles of the nomads of Asia were carts and wagons, two and four wheeled, in ancient times. (See CART; WAGON.) The war-vehicle of the ancients is considered under CHARIOT (which see).

The *wagons* sent by Joseph from Egypt to Canaan, to fetch his father, were no doubt *plaustra*; that is, carts drawn by yokes of oxen. Horses were not used for draft, except in chariots, and the vehicles of Egypt were two-wheeled. This form of carriage is known to have been in use as long ago as 2000 B. C., and its origin is lost in the obscurity of the remote past. The Greek tradition that wheeled vehicles were invented by Erectorius, the fourth king of Athens, about 1400 B. C., is due to the vanity of a nation who considered themselves *ne plus ultra*, in willful forgetfulness of their great instructor, Egypt, from whose fugitives they received so much. Witness Cecrops and Danaus, and the fact that Thales, Pythagoras, Aristotle, Plato, Solon, Herodotus, and others of their sages, were indebted to the land of the Nile for their eminence in science and arts. It is also quite evident that they improved upon their instructors in both.

The natives of China and India used carts from an early date, which cannot now be determined; the modern Indian cart is a good deal like its predecessor. So clumsy are they that the palanquin is likely to maintain its hold for a while yet.

The wandering Scythians from time immemorial covered their wagons with felt and with leather. (See CART; WAGON.) Athenæus, in the *Deipnosophists*, refers to "Polemo, in his treatise on the *wicker-carriage* mentioned by Xenophon."

The *hamaxa* (*'ama axŏn*, of two axles) was a four-wheeled covered wagon of Persia and Greece, similar to the *carpentum* of the Romans. The body of Alexander was transported in a *hamaxa*.

The Romans had vehicles with one wheel, adapted to be drawn by slaves, and also had two and four wheeled vehicles. They also had carriages adapted for two, three, and four horses.

The use of pleasure-carriages in the city of Rome was forbidden during the republic.

Carts disposed as a circumvallation were the ordinary field and camp fortifications of many nations of antiquity, — the Scythians, Cimbri, Helvetii, Goths, Gauls, Britons, etc. The name is from the Celtic, appearing with its Latin termination as *carrus* or *carra*.

Such a fortification was known to the Romans as a *carrago*.

The Roman *arcena*, of which mention is made in the Twelve Tables, was a covered carriage used by the sick and infirm.

The *carpentum*, seen on antique coins, was a two-wheeled car with an arched covering.

The *carruca*, mentioned by Pliny, had four wheels, and was gorgeously trimmed. No springs.

When Rome fell, carriages and that peculiar form of luxury fell into disuse, and eventually into disrepute.

Smith's "Dictionary of Greek and Roman Antiquities" will enable the student to pursue the matter. See in that work, in addition to the above, *Pilentum*, *Rheda*, *Cisium*, *Covinus*, *Essedum*, *Currus*, *Plaustrum*, *Sarracum*, *Petorritum*.

Down to the sixteenth century, kings, popes, ministers, and magistrates made their progresses and journeys on the backs of animals. During the fifteenth and sixteenth centuries covered carriages were used by women of rank, but it was considered disgraceful effeminacy for men to use them. In 1545 we read of a certain duke who was permitted, as a favor on account of his sickness, to ride to the baths in a covered carriage.

In 1550, three coaches were used by three of the dignitaries of the city.

During the sixteenth century carriages were introduced into Spain, Portugal, England, and other countries.

The practice gradually became more general, and in 1613 we find that ambassadors appeared in coaches at a public solemnity at Erfurth.

The carriage of Henry IV. of France had no springs or suspension-straps. The roads were neither graded nor graveled, and were almost impassable in bad weather. Horseback and pack-horses were the order of the day for passengers and freight. The magnificent Roman paved roads were forgotten.

The modern coach is claimed by the Hungarians,

who say that it derived its name from *kotsce*, and that their king, Matthias Cervinus, was the first who rode in one. An edict of Philip the Fair, 1294, refers to their use, and forbids them to the wives of citizens. They were for a while restricted to the sick, to royalty, and to ambassadors.

A number of instances are cited in English history where they were used, but the roads were so execrable that the hack and pack-horse were used in England until about 1700. The making of roads preceded the extensive use of carriages, and rendered it possible. The Romans knew how important an agent in civilization were the roads, and the memorials of their genius yet remain in Europe. Facility of transportation is necessary to progress, and the early nations were either maritime or dependent upon some great river which was the artery of the empire. Witness the Mediterranean, the Nile, Euphrates, and Tigris; these waters washed all the lands of historic interest from Noah to Constantine. We must except "far Cathay," — China.

Stowe dates the making of coaches in England from 1555, and credits Walter Rippin with the making of the same. The canopies of these coaches were supported by pillars on the bodies, surrounded by curtains of cloth or leather, which were folded up when so desired. They were heavy, clumsy, and destitute of springs. They were driven by a postilion, and where four horses were used, the man who rode the near wheel-horse drove the leaders with reins. The driver's seat was added at a later period. Glass windows were added in 1631 in the carriage of Mary of Spain, the queen of the Emperor Ferdinand III. If the carriage of Henry IV. of France had been furnished with windows in 1610, Ravaillac would have been obliged to choose another mode of assassinating him. The carriage of Louis XIV. of France, 1643, was suspended from springs. The first state coach in England was that of Elizabeth. See COACH.

Stage *wagons* were introduced into England in 1564, and coaches for hire plied in London in 1625. Stage *coaches* were introduced into England by Jethro Tull, about 1750, and were employed to carry the mail in 1784. Before this time it was carried on horseback. See COACH.

See VEHICLES for list of devices for land locomotion, which are treated under their respective heads.

For water locomotion, see VESSELS.

Vehicles are now proposed to be made of india-rubber, all but the axles and tires.

The wood in England differs from our own. While both countries possess oak, beech, ash, and elm, the two latter differ considerably from our timber having the same names, and the English forests are destitute of many varieties which are useful to us in making the wheels, hounds, bodies, tongues, panels, etc. of carriages. Such are hickory, black and white walnut, cherry, maple, yellow poplar, locust, gum, etc.

In England, *ash* is used for the skeleton of the body of superior carriages, and beech for inferior; *elm* is used for strong planking and hubs; *oak* for spokes; *mahogany* or *cedar* for panels; *pine* and *fir* for floor and roofing; *fustic*, *lancewood*, *birch*, *sycamore*, *chestnut*, and *plane-wood* are also used.

In Australia the naves are made of blue gum, the spokes of the iron-bark tree.

2. (*Carpentry.*) The timber frame supporting the steps of a wooden stair. *A rough-string; a carriage-piece.*

3. The pendants from which a sword is suspended from the belt. *Sling; sword-sling.*

4. (*Printing.*) *a.* The frame on rollers by which the bed, carrying the form, with the *tympan* and *friskct*, is run in and out from under the platen.

b. The frame which carries the inking-rollers.

5. (*Machinery.*) A portion of a machine which moves and carries an object; as, —

a. The *log-carriage* of a sawing-machine.

The *bit-carriage* of a boring-machine, which carries the bit and is advanced to the work.

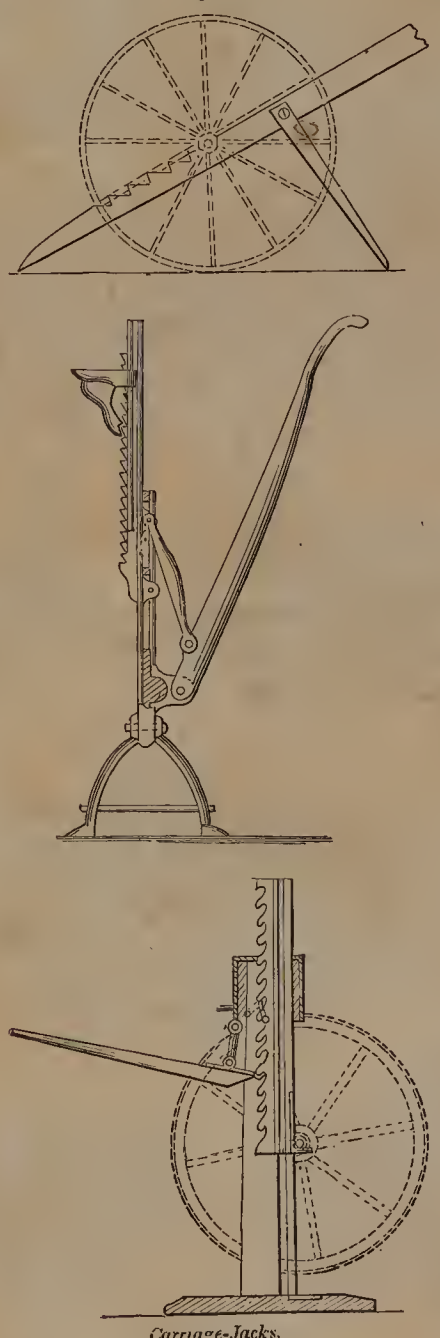
b. The *carriage* of a mule-spinner, which travels towards and from the creel on which the bobbins are skewered.

c. Of a horizontal shaft: the bearings in which it turns.

Car'riage-bolt. A screw-bolt, usually with a chamfered head, square neck, and threaded shank, for use in carriage-making. See BOLT, Fig. 767.

Car'riage-brake. A retarding arrangement for carriages when descending a hill, to prevent horses

Fig. 1133.



Carriage-Jacks.

from starting too readily or moving too fast. It usually consists of a foot-lever connecting by rods to the brake-bar, which applies the shoes to the wheels.

Car'riage-bridge. A roller-bridge to be moved up a glacis and form a bridge from counterscarp to scarp, for the passage of the attacking column.

It has beams and uprights. The latter act as posts, to rest on the bottom of the ditch, and are shiftable to adapt them to the depth of the ditch or fosse.

Car'riage-coup'ling. 1. The coupling of a carriage unites the fore and hind carriages. It is called the *perch* or *reach* in carriages that possess it, but in many modern carriages is dispensed with, the bed resting on the fore and hind carriages, forming the the only coupling.

In wagons, the coupling is a pole, whose forward end is held by the king-bolt in the fore-carriage; the hind end passes through an opening between the hind axle and bolster, and the hounds of the hind axle are fastened to the pole by a pin.

2. A means of uniting the bed to the fore-carriage. It usually consists of a king-bolt, which forms the pintle on which the fore-carriage turns, and the fifth wheel, which is bolted to keep the portions from bouncing apart.

Car'riage-guard. A plate on the bed of a carriage where the fore-wheel rubs in turning short.

Car'riage-jack. A lever-jack, made in various ways, designed to lift an axle, so as to raise a wheel above the ground, in order that it may be removed from the spindle for greasing or repair. The illustrations are self-explaining. (Fig. 1133.)

Car'riage-lock. (*Vehicle.*) A fastening for a carriage-wheel, to restrain its rotation or impede its freedom of movement in descending a hill. A *brake.*

Fig. 1134.

Carriage-Lubricator.

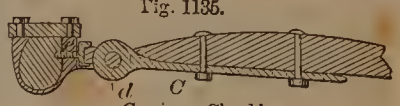
Car'riage-lu'bri-ca'tor. A means for lubricating a carriage-wheel box and spindle without removing the wheel from the axle; a self-feeding device, which will supply the wheel for a considerable time.

Fig. 1134 shows five different forms of the device. The upper one on the left has a movable screw-stopper; alongside of it is one which has a reservoir and cotton wick to supply oil; another has a spring lid to the oil-supply hole; the lower two are reached by unscrewing the stopper-lids of the reservoirs.

Car'riage-piece. (*Carpentry.*) One of the slanting pieces on which the steps of a wooden staircase are imposed. A *rough-string.* The upper end rests against the *apron-piece* or *pitching-piece,* which is secured to the joists of the landing.

Car'riage-shack'le. The bar *C,* which connects the axle-clip to the thill or shaft; *d* is the pintle.

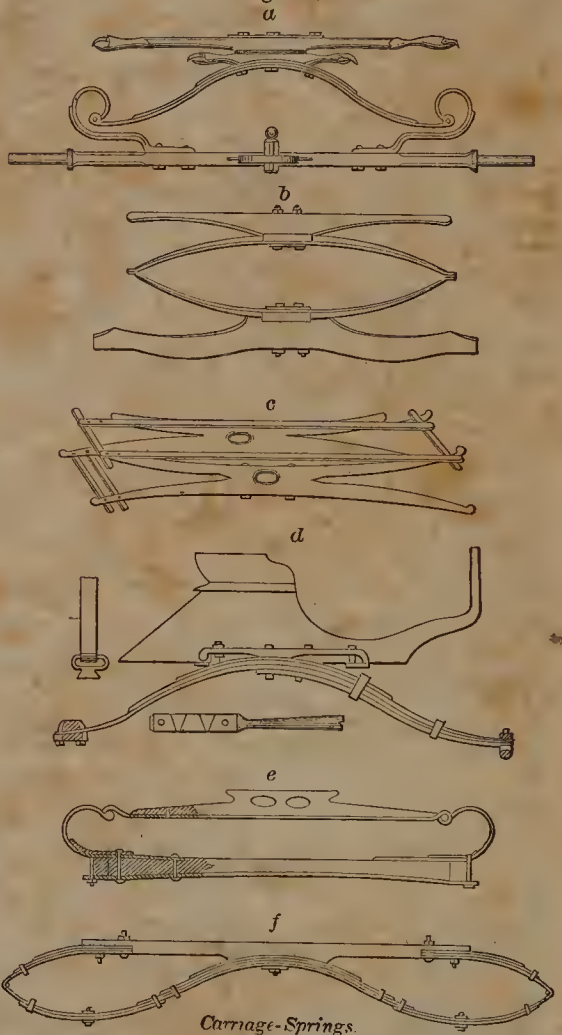
Fig. 1135.



Carriage-Shackle.

Car'riage-spring. An elastic device interposed between the bed of a carriage and its running-gears, to lessen the jar incident to inequalities in the road,

Fig. 1136.



Carriage-Springs.

and the saltatory and rolling motion of the bed itself. Several examples are shown, of which —

a has semi-elliptical springs hung upon the ends of C-springs attached to the axles.

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